DISEASES

of the FOOT

By

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TO
MY WIFE

PREFACE TO THE SECOND EDITION

The first edition of this book was written to fill a need among physicians as expressed by them to the publishers Its reception was gratifying and demand for it has continued

The fundamental concepts of functional treatment of disturbances of the foot have not changed, but have been more firmly established by the intervening years of clinical experience Function is the primary consideration in the treatment of any condition affecting the foot and has been the theme throughout this text.

The treatment of pes valgoplanus with corrective shoes and correct gait has received wide acceptance. This chapter, accordingly has been rewritten for clarification and more detailed illustrations have been used

The treatment in infancy of congenital talipes equinovarus and congenital pes valgoplanus with cohesive bandage has been included. An ambulant brace for maintaining overcorrection of the clubfoot until muscle balance is established is illustrated. Technical improvements in the surgical correction of hallux valgus hammer toe and metatarsalgia are described

The chapter on infections has been revised to include the current use of the antibiotics

Advances made during World War II in the treatment of circulatory disturbance have been studied. Those which proved effective have been included A new and effective method for treatment of chronic thrombophlebitis using anticoagulants and antibiotics is presented in detail.

Illustrations have been added to illuminate the text further Many of the older ones have been replaced by careful selection from our files

It has been the author's earnest desire to make this a practical book for use by the physician in the care of his patients

Dr E J Cummins, Jr my associate, has been unstinting in his efforts in every phase of the revision Louise Reinecke, Adele Hauser Donlin and Mary Burdahl have been invaluable in their aid in preparation of the manuscript and new illustrations

I deeply appreciate the encouragement and help of W B Saunders Company

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EMIL D W HAUSER

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ANATOMY

The normal human foot is a bony structure supported by ligaments and controlled by muscles. It depends upon the vascular and lymphatic systems for its nourishment and on the nervous system for its control. This structure is protected by the subcutaneous tissue, skin and nails.

Bones. The osseous structure of the foot has twenty-six bones not including the accessory bones. The posterior support of the foot is

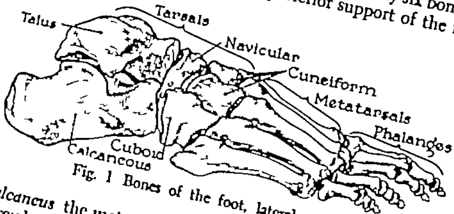


Fig. 1 Bones of the foot, lateral aspect

the *calcaneus*, the *metatarsal* bones constitute the anterior support. The weight of the limb is thrust upon the *talus* which rests upon the calcaneus. Force is transmitted through the head of the talus to the *navicular* bone. The navicular in turn is connected to the *cuneiform* bones and these to the metatarsal bones. At the same time the navicular rests upon the *cuboid* bone, and the cuboid receives pressure from the fourth and fifth metatarsal bones and posteriorly from the calcaneus. In this way the foot as a whole forms an arc resembling a hemisphere. The heads of the first and fifth metatarsal bones are on one plane and the second, third and fourth are higher so that there is a transverse arch in the region of the heads of the metatarsal bones. This arch however is obliterated

when weight bearing takes place. The *phalanges* make up the skeletal structure of the toes The outer longitudinal arch is firmly constructed and is made up of the calcaneus the cuboid and the fifth metatarsal bones at times the fourth metatarsal bone is included (Fig 1) The inner arch is made up of the calcaneus the talus, the navicular the cuneiform and the first metatarsal bones (Fig 2) The second and third metatarsal bones are also included as part of the inner arch

It is clear, then, that the calcaneus is the most important structure of the foot· of great importance also is the first metatarsal bone, the fact that it is much heavier than the others indicating great functional demand. The outer longitudinal arch is firm and strong and is a useful static support. The inner longitudinal arch acts as a spring and per

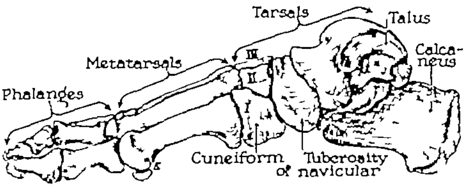


Fig. 2 Bones of the foot, medial aspect.

mits elasticity in the gait The height of the medial arch is measured *from the tuberosity of the navicular bone to the floor* The head of the talus is the highest point of the arch but the position of the navicular is more readily identified The relationship of this height to the distance from the calcaneus to the head of the first metatarsal *bone can be used as an index of the height of the arch* This index was found to be 0 57 in adults and 0 21 in the newborn The small index in the newborn is due to the horizontal position of the calcaneus

Articulations. *The articulations in the foot are of two general* types The ankle and interphalangeal joints are typical *hinge* type. Dorsiflexion and plantarflexion occur at the ankle joint The tarsal and tarsometatarsal joints are of the *gliding* type Supination prona*tion inversion and eversion occur as an aggregate of motion in the* tarsal and metatarsal system Motion at any single joint is slight

Ligaments The ligaments of importance are those extending from

the tibia to the fibula from the tibia to the calcaneus and from the tibia to the navicular Anterior to the ankle are the broad thin, membranous ligaments, the *transverse crural* and *cruciate crural* (which retain the extensor tendons of the toes the tibialis anterior and peroneus tertius muscles) (Figs 3 and 4) There is a thin posterior capsule reinforced by the *laciniate* ligament, which retains the flexor tendons as they pass the ankle. These are thin structures

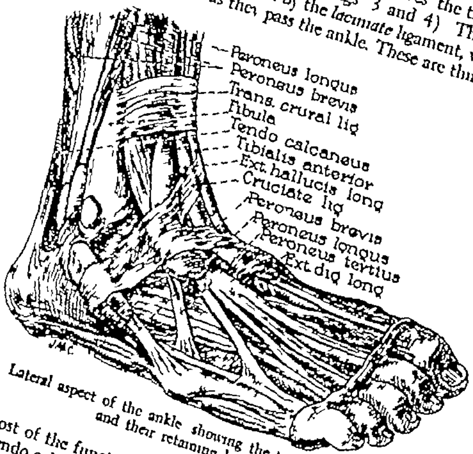


Fig. 3 Lateral aspect of the ankle showing the tendons mucous sheaths and their retaining ligaments

since most of the function of the posterior ligament is taken over by the tendo achillis The medial lateral ligament the *deltoid* is a strong flat triangular structure attached to the medial malleolus the anterior fibers run to the navicular the middle fibers go straight down to the sustentaculum tali of the calcaneus and the posterior fibers pass backward to the inner side of the talus (Fig 5) Some deep fibers run from the medial malleolus to the talus The *lateral* ligament is composed of three parts the *anterior talofibular* ligament which passes from the lateral malleolus forward to the talus the *posterior talofibular* ligament which runs almost horizontal to the tubercle of the talus and the *calcaneofibular* ligament which forms a rounded cord running from the malleolus to the lateral sur

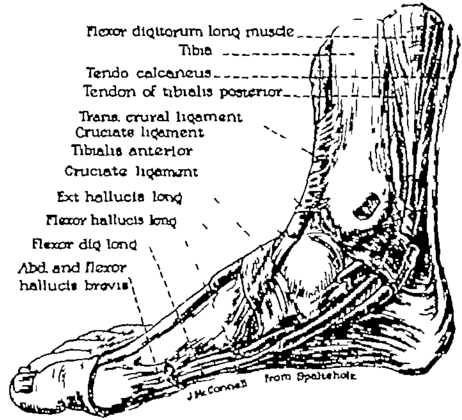


Fig 4 Medial aspect of the ankle, showing the tendons, mucous sheaths and their retaining ligaments

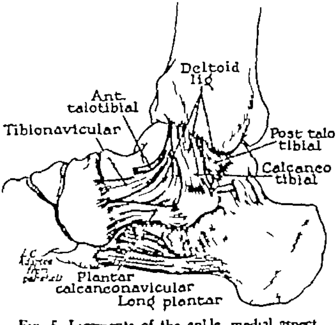


Fig 5 Ligaments of the ankle, medial aspect

face of the calcaneus (Fig 6) This ligament is important in the consideration of sprain and fracture at the ankle.

The *plantar calcaneonavicular* ligament is a powerful and important structure which runs from the sustentaculum tali to the navicular bone and has an attachment to the deltoid ligament (Figs 5 and 7) On its dorsal surface it supports the head of the talus underneath it runs the tendon of the tibialis posterior, which in turn supports it. This is a heavy ligament that acts as a decided obstruction in the reduction of talipes varus It is also significant

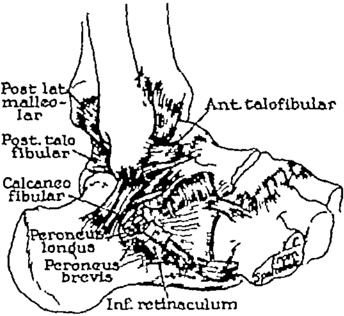


Fig. 6 Ligaments of the ankle, lateral aspect

in the prevention of pes valgoplanus since it supports the head of the talus Further support of the longitudinal arch is received from the *long plantar* ligament which is attached posteriorly to the calcaneus and branches to the cuboid and to the bases of the second, third fourth and fifth metatarsal bones The short flexor of the fifth toe and the adductor of the great toe are attached to the sheath of the peroneus longus This is significant inasmuch as a flattening of the arch will put tension on the peroneal muscle and fascia and this in turn will cause a contracture of the fifth toe as well as an adduction of the great toe (hallux valgus) There is also the *plantar calcaneocuboid* ligament which binds the calcaneus to the cuboid These ligaments act as supportive structures to the longitudinal arch Anteriorly there are some transverse ligaments attaching the heads of the metatarsal bones on their plantar aspects these tend to pre

vent spreading of the heads of the metatarsal bones and help support the transverse arch.

The plantar aponeurosis is a *strong layer of fibrous tissue arranged* in a longitudinal direction and attached posteriorly to the calcaneus. It spreads forward in a fan-shaped manner and sends prolongations to each toe. It is thick at its apex and attachment near the heel. Fibrous bands connect it to the skin It covers the muscles and sole

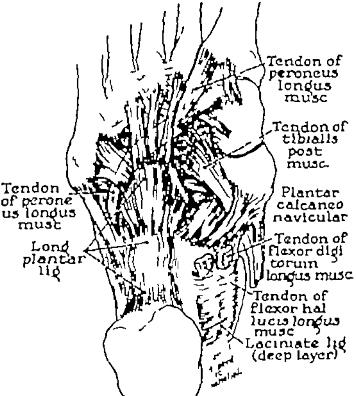


Fig 7 Ligaments of the sole of the foot.

of the foot and helps protect them Attached to the plantar aponeurosis as well as to the calcaneus is the flexor digitorum brevis This *acts as a flexor to the four small toes* Thus when the plantar aponeurosis is elongated as in pes valgoplanus there is a tendency toward contracture of the toes Whenever a tendon angulates at an articulation it is held in place by strips of fascia called "retinacula" The peroneal tendons are held in place by two of these (superior and inferior) retinacula one running from the fibula to the calcaneus and the other being attached entirely to the calcaneus

If these become too loose or are torn the peroneal tendon may subluxate

Muscles. Fully as important as the ligaments if not more so for the normal use of the foot, are the muscles The usual anatomic description of individual muscles will not give adequate information in the study of the foot, since the muscles must also be considered with regard to such normal activities as standing walking running and jumping In these capacities no muscle retains individual action but all coordinate to perform a definite function Pure extension and flexion or adduction and abduction are under normal conditions rarely executed by the foot. It cannot be too strongly emphasized that the actions of the various muscles as given in textbooks on anatomy apply mostly to the nonweight bearing foot They are thus of some academic interest. In practice however, the stresses fall on the leg during these normal activities when the foot is fixed on the ground and the structures above move over it and it is in this position that muscular actions are best considered Thus the primary action of the leg muscles is to balance the leg on the foot in such a manner that the weight of the body falls on that part of the foot which should be carrying it at the particular instant of the active cycle under consideration Another activity of the muscles is to help counterbalance the deforming forces which develop when the weight of the body falls in unusual positions

During locomotion the foot can be considered an organ of propulsion and may be thought of as a two-armed lever The powerful posterior group of muscles pull on the short lever of the projecting calcaneus There is a plantar muscle pull by eight muscles which have power sufficient to pull about 20 pounds the three dorsiflexors, on the other hand can pull only about 10 pounds The plantar flexors are approximately four times as heavy as the anterior group Nevertheless these proportions are balanced The powers are equalized by other mechanical factors in standing, walking and in similar normal functions The posterior group of muscles are important in walking running and in going up and down stairs Sections of the foot of the Negro reveal a longer calcaneal projection or a longer posterior lever than usual and the lengthening of the posterior lever supposedly gives an advantage in carrying out the functions of running and jumping The increased capacity of the posterior group is not in proportion to its size since better leverage is frequently an important factor

There is a coordinated arch-lifting power of the *tibialis posterior*

peroneus longus tibialis anterior and *flexor hallucis longus* muscles If the tibialis posterior muscle is contracted and the peronei are contracted at the same time, there is a tendency for the arch to be pulled together When this happens the transverse arch is also raised

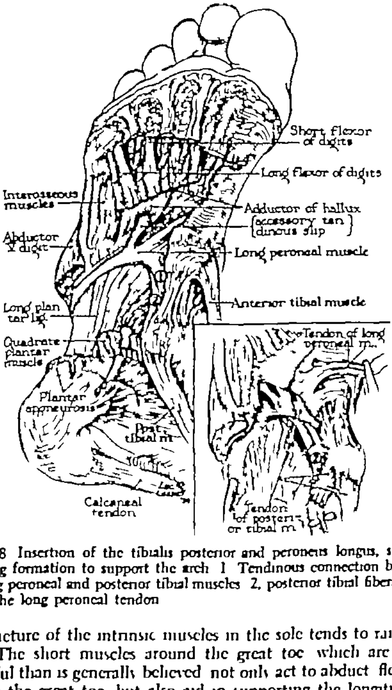


Fig. 8 Insertion of the tibialis posterior and peroneus longus, showing the sling formation to support the arch 1 Tendinous connection between the long peroneal and posterior tibial muscles 2, posterior tibial fibers going under the long peroneal tendon

Contracture of the intrinsic muscles in the sole tends to raise the arch The short muscles around the great toe which are more powerful than is generally believed not only act to abduct flex and adduct the great toe but also aid in supporting the longitudinal

arch Cooperating with the short muscles particularly those of the fifth toe they increase the stability of the foot.

The abductor of the great toe has lost its function to a great extent in civilized countries The power of abduction is present in the new born and is reported to be present in the bare footed natives of South Africa The appearance of the foot in primitive races also suggests the presence of the function of abduction The tibialis posterior arises from the posterior interosseous membrane as well as from the tibia and fibula, and inserts into the tuberosity of the navicular giving off fibrous portions to the sustentaculum tali as well as to the three cuneiforms the cuboid and the bases of the second third and fourth metatarsal bones The peroneus longus runs across the sole from the lateral to the medial side, to insert in the first cuneiform bone and the base of the first metatarsal bone. These two muscles therefore, act as a sling for the arch (Fig. 8)

Tendon Sheaths. The tendon sheath is made of two layers the visceral and the parietal, which join to form a mesentery containing the blood vessel that supplies the tendon The folds of the tendon sheath are sufficiently redundant to permit them to glide past each other without putting tension on the mesentery

The tendon sheaths are protected by layers of fibrous tissue In the region of the ankle this consists of the transverse crural ligament and the cruciate crural ligament The peroneal tendon sheath is protected on the plantar surface by the long plantar ligament The distal ends of the plantarflexor tendons are covered by a thick layer of fibrous tissue, except for the proximal half The sheath is therefore, vulnerable at this unprotected point

Tendon sheaths in the foot since they are rarely infected, are relatively unimportant as compared to those of the hand For a detailed description of the tendon sheaths around the ankle, the reader is referred to textbooks of anatomy or to the article by Grodinsky

Fascial Spaces. On the plantar surface of the foot are two septa the medial and lateral which extend upward from the plantar aponeurosis and divide the foot into three main fascial compartments The *medial* fascial space lies below the abductor hallucis and runs along the lumbrical muscles The *lateral* fascial space lies below the abductor digiti quinti

The central compartment contains four fascial spaces which lie one above the other the first lies between the plantar aponeurosis and the flexor digitorum brevis the second lies between the flexor

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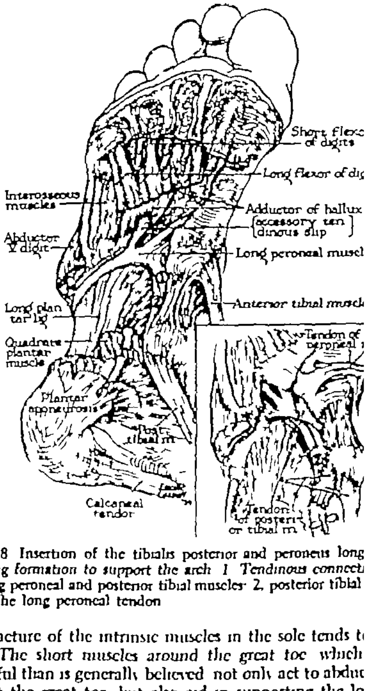


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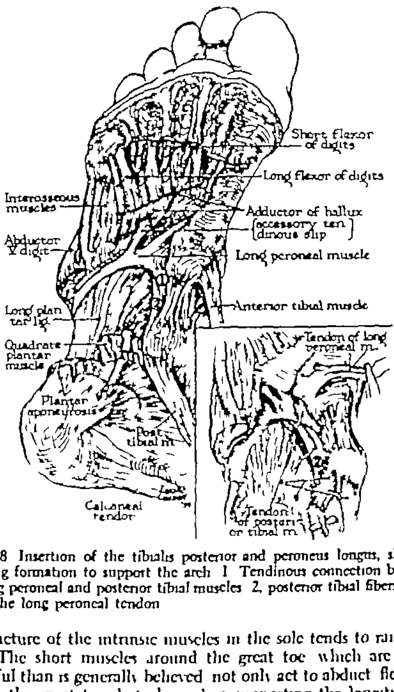


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course of the lumbrical muscles and from there may drain to the dorsum of the foot. On the dorsum of the foot are two spaces a subcutaneous space and a subaponeurotic space (Figs 9 and 10)

Vessels The dorsum of the foot is supplied by the *dorsal artery* which is a continuation of the *anterior tibial artery* and is located

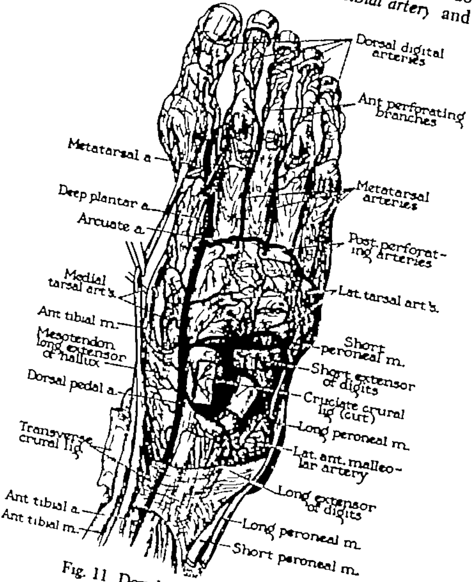


Fig. 11 Dorsal arteries of the foot

between the first and second metatarsal bones It passes forward over the dorsum of the foot, with a lateral branch just below the ankle to the tarsus as well as a small medial vessel to the medial side of the ankle Distally near the bases of the metatarsal bones it forms an arch from which branches extend to the lateral side of the

digitorum brevis and the quadratus plantae; the third lies between the quadratus plantae and the tarsal and metatarsal bones, and the

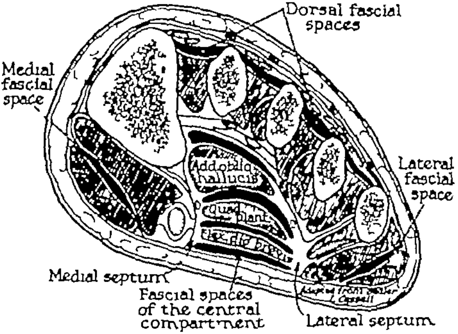


Fig. 9 Cross section of the foot, showing the fascial spaces

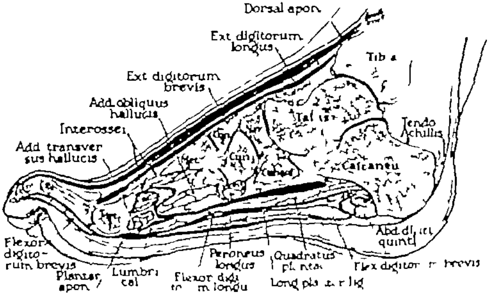


Fig 10 Longitudinal section of the foot showing the fascial spaces.

fourth lies deep to the adductor obliquus hallucis The metatarsal interspaces drain into the third and fourth fascial spaces along the

The arterial supply to all the digits is extremely rich so that, no matter what compression is experienced there is little danger of obliteration of the blood supply since not all the vessels will be cut off (Figs 11 and 12)

The arteries of the foot vary in different persons, several anomalous patterns having been described This alteration in the position

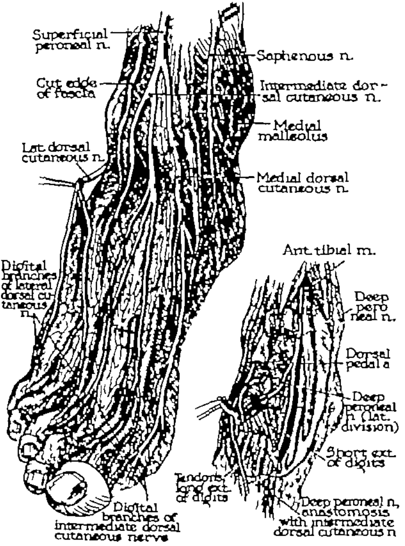


Fig 13 Nerves of the dorsum of the foot.

of the vessels must be taken into consideration in properly evaluating the pulse taken from the dorsal and tibialis posterior arteries in any study of vascular diseases

The dorsum of the foot has a complete plexus of veins which drain into the great saphenous vein The plantar aspect of the foot is practically devoid of superficial veins The lymphatic vessels of

second toe; it supplies the third fourth and fifth toes. The area between the lateral tarsal artery and this arch frequently has a poor vascular supply and for this reason there is a tendency for poor healing of incisions made in this area The distal end of the vessel supplies the medial side of the second toe and the entire first toe.

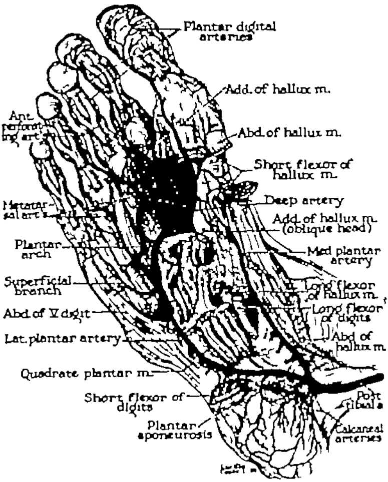


Fig. 12 Plantar arteries, deep view

The deep *plantar artery* perforates between the first interosseous muscle to unite with the end of the lateral plantar artery

The *posterior tibial artery* comes down between the medial malleolus and the calcaneus to reach the plantar surface where it divides into a *medial plantar artery* and a *lateral plantar artery* The latter the larger of the two forms an arc at the bases of the metatarsal bones and sends branches to all five toes The medial plantar artery continues along to end on the medial side of the first toe

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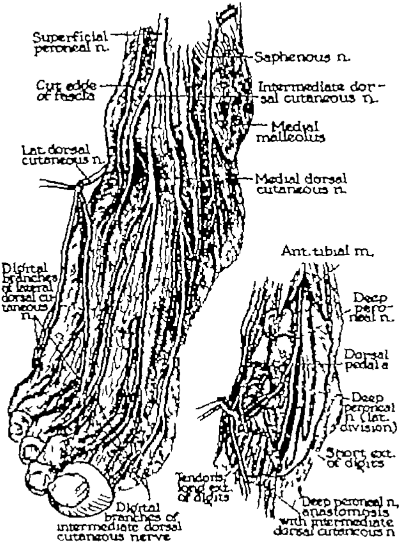


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the lower extremity consist of two sets superficial and deep and their distribution corresponds closely to that of the veins The sole and inner half of the dorsum of the foot drain along lymphatics or interlymphatics that course along the inner aspect of the leg and find their way to the inguinal lymph nodes The outer aspect

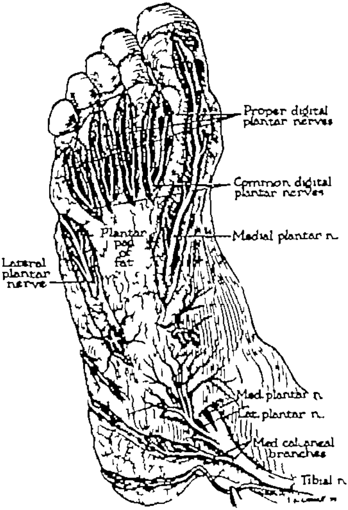


Fig 14 The plantar nerves, superficial

of the dorsum of the foot and the outer toes are drained into vessels which go along the external saphenous vein to nodes in the popliteal space and then to the deep femoral nodes

Nerves The posterior *tibial* and *peroneal* nerves supply the foot except for the inner border supplied by the *saphenous* nerve and the outer surface supplied by the *sural* nerve (Fig 13) The *plantar* nerves are branches of the posterior tibial nerve and supply the plantar surface of the foot The medial plantar nerve supplies the

first second and third toes and the medial half of the fourth toe, the lateral plantar nerve supplies the outer half of the fourth toe and the fifth toe (Figs 14 and 15) *The dorsum of the foot* is supplied by the superficial peroneal nerve, except for the first inter digital space, supplied by the deep peroneal nerve The bottom of

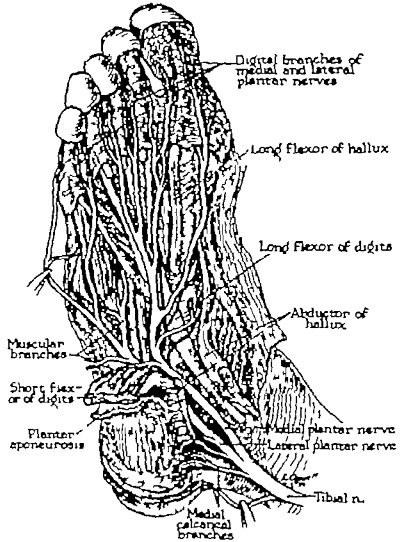


Fig 15 The plantar nerves deep

the heel is innervated by *a branch from the tibial nerve called the medial calcaneal* nerve. The segmental innervation of the foot is not so definite as that in the hand because of the greater degree of rotation during development (Fig 16) The dorsum and lateral side of the foot are supplied largely by the *fifth lumbar* nerve, the medial surface by the *fourth lumbar* and *first sacral* and the region

of the heel by the *first sacral* The sole of the foot receives fibers from the fifth lumbar and first sacral

The muscles which control the foot are likewise innervated by the tibial and peroneal nerves The triceps surae posterior tibial flexors

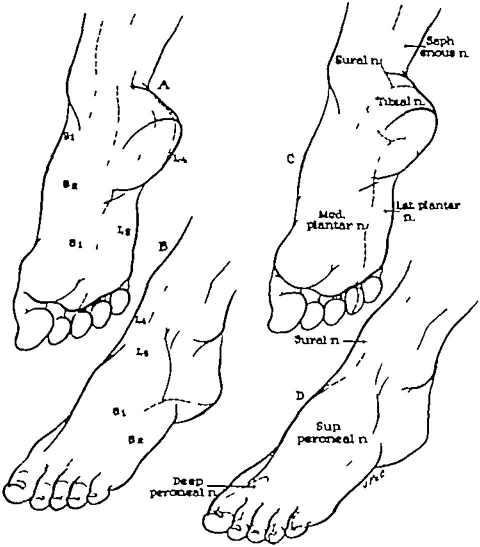


Fig 16 Cutaneous innervation of the foot *A* and *B* segmental distribution *C* and *D* peripheral nerve distribution S_1 and S_2, first and second sacral nerves; L_4 and L_5, fourth and fifth lumbar nerves

of the toes and small muscles of the foot are innervated by the tibial nerve and its branches The extensors of the toes tibialis anterior and peroneus tertius receive fibers from the deep peroneal nerve and the peroneus longus and brevis are supplied by the superficial peroneal nerve

Skin The skin on the sole of the foot is thick, whereas that on the dorsum is thin The dorsum of the foot has loose areolar subcutaneous tissue which takes up fluid readily in edema and becomes swollen and inflamed in infection The skin on the sole is thickened by hypertrophy particularly in those areas where pressure is applied Beneath the skin is a fibrotic adipose tissue This fibrous tissue interweaves to form a tough mat which acts as a protective wall for the weight bearing bones These structures also protect against abrasions and perforations The skin of the sole is covered with a series of ridges which make a characteristic print such as is made by the fingers These ridges tend to give a better grasping surface, since they give rise to friction

Nails. The nails or *ungues* are horny plates covering the dorsal surface of the distal half of the terminal phalanx of each toe. They are implanted into a groove in the skin by a covered portion called the "nail root The exposed part is called the "body," and its distal part where it is no longer attached is called the "free margin The part beneath the body and root of the nail is called the nail matrix, because from it the nail is produced Under the nail the matrix is raised in a series of vascular longitudinal ridges This vascular tissues gives rise to the color seen through the transparent nail plate

Near the base of the nail the vessels are smaller, and the nail is not adherent to the connective tissue This portion therefore, is white and because of its shape is called the "lunula " The epidermis covers a narrow margin of the proximal part of the nail plate to form the cuticle It continues along the lateral margin of the nail and becomes connected with the under surface of the nail a little behind its free margin The cuticle and nail plate thus become continuous structures Both are derived from the epidermis

The superficial horny part of the nail consists of a thickened stratum lucidum The thin cuticular fold along the lateral margin is called the eponychium " and along the proximal margin the cuticle and the eponychium are derived from the stratum corneum The deeper part of the nail consists of stratum mucosum The matrix is made up of the papillae, which are covered with columnar cells On these in turn are superimposed rounded or polygonal cells, and the more superficial cells become broad thin and flattened The nail grows in length by proliferation of cells at its root It grows thicker from the part of the stratum mucosum which lies under the lunula The nail always grows in a straight line from the root Injury to the stratum mucosum beneath the lunula results in alteration in the thickness of a nail (Fig. 17)

Retention of the Arch Altered position of the foot and the simultaneous changes in the bones result in the development of the arches of the foot The retention of these arches is due to certain definite structures. First of all the high development of the calcaneus increases the height of the posterior part of the arch Secondly the plantar aponeurosis acts as a bow string to retain the arched position of the bones Further support of the arch is obtained from the great development of the deltoid plantar calcaneonavicular and

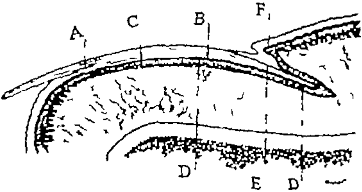


Fig 17 Longitudinal section of the nail A, Nail plate; B lunula C, nail bed, D matrix; E, nail root, F nail wall (From Pardo-Castello Diseases of the Nails Charles C Thomas)

long plantar ligaments Furthermore, the short flexors on the plantar surface of the foot tend to retain the bowed position of the tarsal bones The *secondary attachments of the tibialis posterior make it* traverse beneath the arch The long peroneal acts in a similar way from the opposite direction forming a sling to suspend the arch *(see Fig 8)*

REFERENCES

Grodinsky M A Study of the Fascial Spaces of the Foot and Their Bearing on Infections Surg Gynec. & Obst., 49 737 1929 A *Study of the Tendons Sheaths of the Foot and Their Relation to Infection* Surg Gynec & Obst., 51-460, 1930

Keith Sir Arthur The History of the *Human Foot and Its Bearing on Orthopaedic Practice* J Bone & Joint Surg 11 10 1929

Morris, H Human Anatomy edited by C M Jackson 9th ed Philadelphia, P Blakiston s Son & Co 1933

Morton D J The Human Foot New York Columbia University Press, 1935

2

PHYSIOLOGY

MOVEMENTS OF THE FOOT

The movements of the foot are never simple, but for the sake of convenience we can speak of four primary movements dorsiflexion, plantarflexion inversion and eversion When the foot moves on its transverse axis we have dorsiflexion and plantarflexion when the

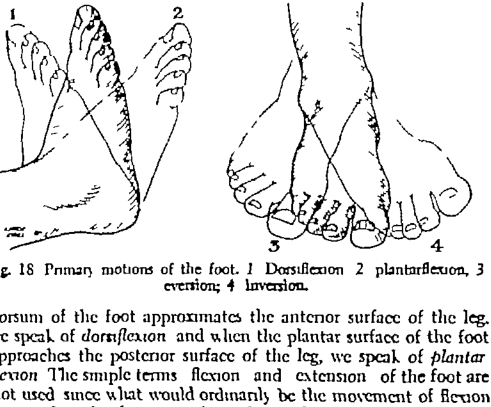


Fig. 18 Primary motions of the foot. *1* Dorsiflexion 2 plantarflexion, 3 eversion; 4 Inversion.

dorsum of the foot approximates the anterior surface of the leg. we speak of *dorsiflexion* and when the plantar surface of the foot approaches the posterior surface of the leg, we speak of *plantar flexion* The simple terms flexion and extension of the foot are not used since what would ordinarily be the movement of flexion is carried out by the group of muscles on the dorsal or anterior part of the limb and these are always called extensors To avoid confusion therefore we speak of this movement as dorsiflexion and the muscles that bring about this movement are called dorsi

flexors" rather than "extensors" of the foot. For clarity the term "plantarflexors" is used for the muscles that bring the foot into plantarflexion. When the foot moves on its longitudinal axis so that the sole is rotated inwardly to face the other foot this is called *inversion*, when the sole of the foot is rotated on its longitudinal axis so that it faces away from the other foot this is called *eversion* (Fig 18)

For the sake of clarity it is necessary to define other movements in the foot "supination" is a rotary movement in the longitudinal axis in which the great toe is lifted away from the floor whereas "pronation" is the opposite movement in which the small toe and

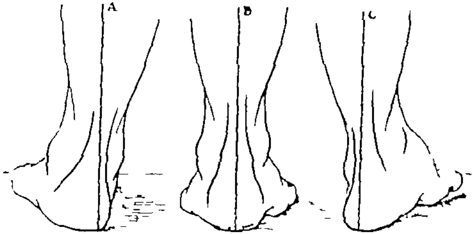


Fig 19 *A* Heel in valgus position *B* heel in normal position; *C* heel in varus position

outer margin of the foot are elevated These movements take place in the foot itself When the foot moves with regard to the axis of the leg, so that the margins of the foot lead in the movements, we speak of "abduction" and "adduction" When the medial margin precedes in the direction of the tibia we speak of "adduction" when the lateral margin precedes in the direction of the fibula we use the term "abduction"

In normal motion the movements of the foot are usually combined, most often in the following manner supination and adduction are associated with plantarflexion pronation and abduction are associated with dorsiflexion Since pronation and abduction are nearly always combined, either one of these terms is used to describe this combination of movements In this text the term "eversion" will be used for this combination of movements for the combination of supination and adduction the term "inversion" will be used

The terminology used in this book with regard to the position of the foot is as follows if in its vertical axis the foot is at a right



Fig. 20 A Adduction, and B abduction of the fore part of the foot

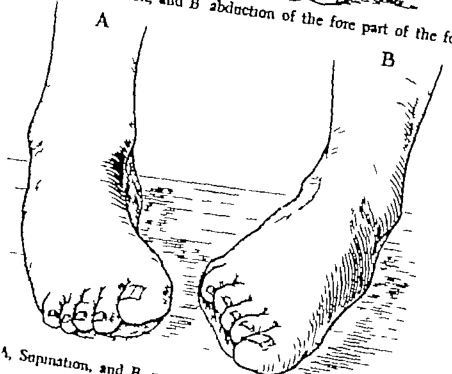


Fig. 21 A, Supination, and B pronation of the anterior part of the foot.

angle to the leg it is in the "midposition" If the angle of the foot to the leg is less than a right angle the foot is "dorsiflexed" and if the angle is greater than a right angle the foot is "plantarflexed"

When the heel is turned out (everted) it is in "valgus" and when the heel is turned in (inverted) it is in "varus" position (Fig 19) When the anterior part of the foot is displaced so that it lies medial to the vertical axis of the leg it is in "adduction" and when it is displaced so that it lies lateral to the vertical axis it is in "abduction" (Fig 20) The foot is in "supination" when the anterior part is elevated on its inner margin and in "pronation" when the outer margin of the anterior part is elevated (Fig 21)

FUNCTIONS OF THE FOOT

The anatomic description has been limited to structures of the foot which are of clinical importance This means structures that have significance with regard to use. Many of the disorders of the foot are primarily disturbances in function The normal functions of the foot are to act as an organ of support for the body (static function) and as an organ of propulsion (kinetic function) The body is propelled forward in walking or running other forms of kinetic function required of the foot are climbing descending, jumping and dancing

The static functions of the human foot are unique inasmuch as man alone stands in an upright position In standing most of the body weight is transmitted directly from the talus to the calcaneus A certain amount of pressure passes laterally from the talus onto the cuboid and fifth metatarsal bones A lesser degree of weight bearing is transmitted through the head of the talus to the inner side of the foot through the navicular and cuneiform bones to the first metatarsal bone It has been demonstrated that in standing the heads of the second third and fourth metatarsal bones receive some of the body weight The amount of pressure occurring at the first and fifth metatarsal bones however is normally greater than that occurring at the heads of the other metatarsal bones The toes receive a slight amount of weight in standing they also aid in adjusting the foot to the walking surface

The posterior part of the foot receives most of the weight of the body and is the most stable part The small amount of lateral movement present occurs at the talocalcaneal articulation The lateral part of the foot which receives some of the transmitted weight is a low firm bony arch which assures st[illegible] and stability The first metatarsal bone is relatively large[illegible] greater functional demand Wit[illegible] others indic[illegible] the metatarsal bones form a trans[illegible] of weight there is to some [illegible] the

This transverse arch serves to adjust the foot to different types of walking surfaces and thus increases its stability The obliteration of the transverse arch is associated with an increase in the breadth of the foot. Normally, with weight bearing the longitudinal arch is lowered and the length of the foot is increased slightly The longitudinal arch acts as a support and at the same time adds pliability to the foot

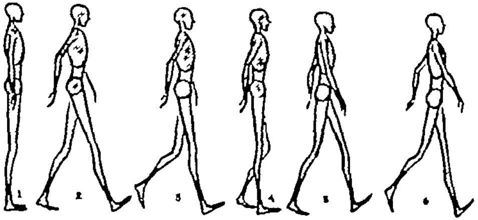
The index of the arch has a normal variation in other words the height of the arch is not a satisfactory criterion of the normal particularly as regards the function of the foot. Nevertheless an extreme alteration of this index would be indicative of an abnormal foot and impaired function In the same way, a great increase in the difference between the index of the weight bearing foot and that of the suspended foot is suggestive of structural weakness and impaired function

The function of the foot depends not only on the osseous and ligamentous structures but also on the coordination of the muscles and on the nervous system The statics of the foot depend on the support of the bony skeleton as well as on the support of the ligaments The manner in which weight is transmitted through the foot depends on the relationship of the bones to each other and this is controlled by the muscles of the foot and the leg A disturbance in the muscles will alter the weight bearing functions of the foot. This disturbance may be in the muscles themselves or it may be in the nerves that control them Injury of a peripheral nerve or nerve root or even of the higher centers in the nervous system could cause muscle imbalance and be responsible for a static disturbance of the foot

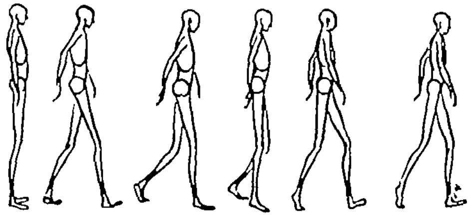
The study of statics in the foot involves a study of all the structures of the body Weight bearing in the foot is related to weight bearing in the lower extremity and to general posture An analysis of all the structures involved would therefore be a Herculean task, not within the scope of this book. This is true also of a study of gait.

In normal gait the weight of the body is transmitted from the talus to the calcaneus and is transferred forward on the outer side of the foot It then crosses over the heads of the metatarsal bones to the inner side of the foot where it is supported by the great toe assisted by the four lateral toes as the foot leaves the floor In walking the right foot is placed forward with the heel resting on the floor and the foot in dorsiflexion The weight rolls over the heel which acts as a fulcrum The posterior group of leg muscles contract to bring the anterior part of the foot in contact with the floor while the

heel is lifted in the air The foot in this case acts as a lever with the fulcrum at the talus and the posterior projection of the calcaneus as a short lever upon which the powerful calf muscles exert their force The flexor muscles of the toes particularly the flexor hallucis longus contract and cause the toes to grip the floor and propel the body forward



Normal gait



Poor gait

Fig 22.

In walking while the right heel is on the floor and the foot is in dorsiflexion the knee is fully extended (Fig 22) As the calf muscles contract and the heel leaves the floor the knee is flexed As the weight is taken over by the toes and the heel continues to rise flexion increases at the knee For a short interval toward the end of this phase in stepping, the entire weight of the body rests on the right foot alone The left foot is cleared off the floor and is swung

past the right foot. With the knee extended, the left heel is brought into contact with the floor The weight of the body is then transmitted onto the left foot in the same manner as for the right foot The foot rolls over the floor At no stage during normal gait is the entire foot flat on the floor Normal gait has been called a rolling gait The foot strikes at the outer corner of the heel, and the weight rolls over the heel and the lateral side of the foot, it then crosses the anterior part of the foot to the medial side and the great toe



Fig. 23 Demonstration of normal gait. Snapshot of an Indian girl on the beach at Manta, Ecuador (Photograph by Heath Bowman)

This is a screwlike movement forward from the lateral to the medial side Just before the toes of one foot leave the floor the other foot is swung forward Then with the knee extended, the heel on the floor and the toes in the air the movements are repeated (Fig 23)

These phases of the movements of the foot in normal gait have been studied by observation by a series of photographs and by analyses of cinematographs and electrographic measurements

Normal gait is dependent not alone on the structures of the foot but also on the structures of other parts of the body Walking

consists in a complicated group of movements and requires the coordination of the muscles of the lower extremities as well as those of the body as a whole. Coordination of the muscles depends on muscle tonus and muscle control and on muscle sense and joint sense Gait also depends on the organs of equilibrium vision the cerebellum and the semicircular canals Many of the movements involved in walking are controlled by reflexes although walking as a whole is a voluntary movement With continuous practice, reflexes are established that make for automatic movements these remain under the control of the higher centers

Since walking depends upon the structures and function of the body as a whole, errors in gait must be sought in sources other than disturbances in the feet A neurologic lesion is likely to be the causative factor in an abnormal gait and a postural disturbance in the trunk can be the explanation of a variation from the normal gait Poor posture—that is an increase of the normal curves of the back—causes a shift in body weight that interferes with normal gait

From all this it follows that an understanding of the disorders of the foot requires study of the structures and function of the body as a whole as well as immediate study of the anatomic and physiologic changes in the foot

Running is a form of locomotion in which the weight of the body is transmitted by fixation of the foot in such a way that only its anterior part touches the ground A second characteristic of running is that there is a phase in which both feet are off the ground at the same time The body is inclined forward so that there is a tendency for the foot to catch the weight of the body The forepart of the foot is brought in contact with the ground as a result of the action of the powerful posterior group of leg muscles The main propulsive force in running is through the action at the knee of the quadriceps femoris muscle A sharp contraction of the flexor muscles of the toes, particularly the flexor hallucis longus helps to bring about the spring which forces the body off the ground

In climbing—for example, in going up stairs—sufficient force is necessary to lift the entire body weight from the heel onto the anterior part of the foot and to sustain the weight until the other foot can be brought up to the next step In descending the weight of the body is placed first on the anterior part of the foot it is held there until the heel comes in contact with the floor and the other foot is brought down to the next step

In jumping the spring is the same as in running but is greatly exaggerated so that the phase wherein both feet are off the ground

at the same time is at its maximum There is great strain on the foot immediately before the jump The coordinated action of the muscles however is adequate to prevent undue strain on the ligaments

In dancing, the weight is carried on the anterior part of the foot in a rhythmic motion so coordinated that it is practically a reflex movement.

There are many other special functional requirements of the foot especially in industry and sports, but the most important functions are always walking and standing.

REFERENCES

Schwartz, R. P and Heath A. L. Factors Which Influence the Foot in Walking: The Stance Phase of Gait J Bone & Joint Surg., 19:431 1937

Schwartz, R P., Heath A. L., Musick, W., and Wright J N Kinetics of Human Gait J Bone & Joint Surg., 16 343 1934

Steindler A Mechanics of Normal and Pathological Locomotion in Man Springfield Ill., Charles C Thomas 1935

3

EXAMINATION

The experience knowledge and viewpoint of the examiner are important in examination of the foot He must have a conception of normal anatomy and physiology and must bear in mind that the foot is only a part of the body and as such is influenced by all the factors that take part in statics and in locomotion Even though the patient s complaint is definitely limited to the foot the causative factor of the disorder may be a disturbance in some other part of the body It is also important for the examiner to keep in mind the patient s point of view The history must first be a presentation of the patient s conception of the development of his symptoms but in order to arrive at a logical presentation of facts the questioning must be directed by the examiner

The history includes first the presenting complaint and its duration Next it takes up the onset of the disturbance, its progress and the causative factors in the patient s opinion The kind of the symptoms directs further questioning with regard to etiologic factors and secondary symptoms Inquiry is made about previous treatment and its effect The amount of disability and the response to normal function are established An impression of the type of person is formed at this time.

The posture, carriage and gait are observed the trained eye will *look not only for disorders in the foot itself but for aberrations* in any part of the locomotor system

The objective findings are obtained by examining the foot by the usual methods observation palpation examination for the movements possible, measurements roentgen examination and special neurologic tests as well as circulatory tests when such are indicated

The patient is then seated and both feet are examined Exposure sufficient to show at least the knee is necessary in every case When

the problem could be influenced by a higher lesion examination must be carried out accordingly When patients come to a specialist because of a foot complaint, a general examination has in most cases been made by the referring physician If this has not been done, however it is the duty of the physician in charge to make such an examination If for example, the complaint is due to arthritis in the foot, it is absolutely necessary to make a complete general examination with special reference to possible foci of infection

Examination of the foot is begun by taking it into the hands and observing any change of color the presence of swelling or atrophy dryness of the skin and the appearance of the nails Calluses corns or deformities of the foot or toes are noted. While the eyes observe, the fingers palpate. The toes are separated to show any interdigital infection or soft corns Both feet are always examined, if one is normal it may be used for comparison

The patient next stands barefoot on a clean towel, and the position of the foot on weight bearing is observed An examining stand with a heavy plate glass top and a mirror at a 35 degree angle beneath it may be used It is ascertained whether there is any apparent lowering of the longitudinal arch or spreading of the forepart of the foot. The patient turns around in order that the heels may be observed The presence of varus or valgus at the heel is established by dropping a real or imaginary plumb line along the longitudinal axis of the lower limb The general alignment of the tibia is likewise observed Any varus deformity is ruled out, and the distance between the internal malleoli is measured to register the degree of genu valgum

The relationship between the calcaneus and malleoli is determined to establish the presence of varus or valgus at the heel. Palpation reveals the type of swelling, bony enlargements increased fluid in the joints thickened joint capsules the presence of an abscess and the quality of muscle tone. Palpation is also important in establishing the existence of inflammatory lesions and in localizing tenderness in the bursa tendon sheath and at the origin of the plantar aponeurosis In addition arterial pulsation is palpated and the veins are examined for engorgement, thickening of the walls and the presence of nodular obliteration A change of temperature is noted by comparing one foot with the other

The movements of the foot are examined by placing it on a stool covered with a clean towel The foot is manipulated to establish the presence of any limitation of motion one foot being compared with the other If there is a deformity the severity of the contracture

is defined by trying to obtain the maximum amount of correction The various joints are checked for any limitation of movement Dorsiflexion and plantarflexion of the ankle are examined to see if there is any loss of motion Normally the foot can be dorsiflexed to an angle of about 75 degrees and plantarflexed to about 145 degrees The talocalcaneal articulation is tested for the amount of lateral movement possible with the foot at right angle The fore part of the foot is brought into pronation and supination testing the movements of the joints in the tarsal area The toes are then plantarflexed and dorsiflexed to check the movements at the meta tarsophalangeal and interphalangeal joints The joints are palpated at this time for the presence of crepitus or exostoses of the articular surfaces

The length of the limbs is measured from the anterior superior iliac spine to the tip of the medial malleolus to determine whether there is any actual shortening The length is also measured from the umbilicus to the tips of the medial malleolus In the presence of an adduction deformity at the hip the length of the limbs, measured from the iliac spine to the internal malleolus may be equal whereas the distance between the internal malleolus and the umbilicus will be shorter on the side of the adduction deformity This is called apparent shortening A pelvic tilt will always be associated with either actual or apparent shortening For this reason it is best that the patient be in a standing position when measured Boards are placed beneath the limb on the lower side of the pelvis until both anterior crests are in the same horizontal line The amount of raising necessary to do this will indicate the amount of shortening present For comparative measurement of the circumference of the limbs the same point must be measured in each The skin is marked at a measured distance from the patella and the circumference measured at this level on each limb

The foot is measured from the heel to the tip of the great toe or to the tip of the second toe, on weight bearing The breadth of the foot is measured at its widest point through the heads of the first and fifth metatarsal bones One foot is frequently larger than the other This variation in size is of primary importance in the fitting of shoes the shoes should be fitted to the larger foot

Roentgenographic examination is an important aid in diagnosis the final diagnosis in certain disorders of the foot depending entirely on the roentgenogram Roentgenograms are particularly valuable in showing articular changes fractures epiphyseal disturbances and tumors or infections of the bones In the presence of a deformity

of the foot the roentgenogram will show the amount of bony change and alterations of the joint, and will be a guide to the method of treatment and the difficulties to be expected in carrying out the correction It is well to remember in taking roentgenograms that the conditions in the anterior part of the foot are best visualized in an anteroposterior view, whereas the lateral view is more satisfactory to show alterations in the posterior part of the foot.

The reflexes are examined routinely and rough sensory examinations are made. If a disturbance is found or suspected an exact examination is carried out; and if the explanation of local change is not obvious, a complete neurologic examination is requested

Circulatory disturbances are tested by observation and palpation When more accurate findings are necessary, roentgenograms of the vessels are made with or without the injection of theobromine. Accurate thermal measurements are sometimes useful. It is important to remember that local static changes are often sufficient explanation for the presence of edema in the foot and ankle.

When an infection is present smears and cultures are useful The identification of bacteria is indicated when the lesions are chronic, unusual or stubborn It may be necessary to aspirate joint fluid to make smears and cultures When the nature of a tumor is not understood, a biopsy may be made.

In addition to routine examination of the foot it is always necessary to examine the patient s shoes The height and weight bearing surface of the heel the thickness of the sole and the rigidity of the arch are observed Frequently the shoe will contain an arch support the type of this support should be taken into consideration in diagnosis Often there is not ample room for the toes The way the sole has been worn will indicate whether weight bearing has been greater on the inner or outer side of the foot. The inside of the shoe may be examined for roughening near the toe cap or at the counter The general appearance of the upper of the shoe frequently denotes the degree of alteration necessary for adaptation to a deformity

4

HYGIENE AND GENERAL CARE

Shoes may be considered a normal requirement of modern civilization since the function of the foot has been altered and the foot requires special measures of protection The original protective covering had as its primary object the guarding against cold and rough sharp surfaces For this purpose a soft leather moccasin served very well Later, firm surfaces demanded more protection for the foot and in warmer climates the leather sandal was a satisfactory solution The majority of people today however have need not only for protection against hard walking surfaces but also against cold heat and moisture In large cities people do nearly all their walking on hard surfaces To devise a covering for the foot that will be able to contend favorably with all these factors is a definite problem At present it is best met by the use of the leather shoe

In addition to these needs for protection there is also an altered functional demand It is obvious that hard walking surfaces subject the foot to a greater strain Furthermore, the mode of living today makes entirely different demands on the foot There is greater occasion for prolonged standing and prolonged sitting One man may have to stand for eight consecutive hours to carry out his work, whereas another may sit at a desk for an equal length of time. In this way gross deviations from the demands that would be normal for the original construction of the foot are to be found in almost all walks of civilized life. The result is a definite need for hygienic measures which will meet these altered demands in the most satisfactory way

Besides these altered functional demands on the foot there has been another stumbling block in the way of proper hygiene. The dominance of style over practical needs in footwear has prevailed for years particularly among women The modern woman however

is gradually experiencing an alteration or liberation from style demands in favor of greater comfort and increased use of the foot, and there has been noticeable improvement in this direction during the last decade With the present trend and style in clothes women have need for various types of shoes, depending on the function required of the foot, they wear low heeled shoes to walk in or for sports during the day and change to high heeled slippers for dancing in the evening This is what we must consider normal it would be just as ridiculous for a woman to wear hiking shoes in the ballroom as it would be for her to wear high heeled slippers for active sports The hygienic measure of protective covering must therefore, take into consideration the present demands This problem in regard to different types of shoes will be considered later

The first covering of the foot is usually a stocking or sock, and the material from which such a covering is made is of some importance. This foot covering has two purposes one is to keep the foot warm and the other is to protect the foot from friction rub by the shoe. It is necessary that the covering be made of material which will absorb moisture Silk and wool have proved satisfactory Wool hose have a certain amount of elasticity which gives some support to the veins In normal feet these considerations are not so important, and nylon hose are quite satisfactory Climatic conditions are a factor in the choice of foot covering It is worthwhile mentioning here that the hose should fit properly They should not be too narrow or too short since hose that confine the feet and toes interfere with normal function and ultimately result in a deformity The hose should of course, be changed frequently

Properly used the house slipper is permissible. The advantages are that one can elevate the feet more readily; slippers are usually lighter and looser than shoes and are therefore more readily slipped on and off They do not however provide adequate protection for the feet against the floor surface; therefore their use as a substitute for regular shoes around the house, particularly in persons with weak feet, will further increase foot disorders A good house slipper has a leather sole and a low heel and is a convenient hygienic measure if it is limited to the use for which it was intended

A primary consideration in the hygiene of the foot is normal exercise, the execution of the physiologic requirements of the foot The type of function varies under different circumstances It is more normal for children to run skip and jump than it is for older people. All people have to walk and stand Prolonged standing is, in every case, a strain that will ultimately lead to a decrease in the

strength of the structures An essential hygienic measure is therefore, to avoid prolonged standing

In occupations that require constant standing some measure should be taken to give frequent periods of rest The economic advantage of periodic rest is today being recognized The actual working time of the traffic policeman for instance, has been broken up so that he gets frequent rest periods With prolonged standing it has been found that there is a definite demand for protection of the foot Thin leather soles are inadequate, and experience has taught the need for heavy soled shoes Thick leather acts as an insulation and has more resiliency than the pavement By the same token the need for a heavy sole would be lessened if the standing were carried out on a cork floor When standing is practically continuous and there is little change of position strain is almost inevitable. Such standing should be avoided whenever possible Walking from one position to another even for a short distance, lessens the strain of prolonged standing

Insufficient use of the feet is also harmful The clerk who sits at a desk all day over a period of years ultimately has a decrease in strength of these structures This will be felt when he attempts to carry out normal function For instance a long hike instead of increasing strength will result in strain and further weakness Unless an effort is made to exercise the foot such a person will ultimately have some disability

Venous stasis results when the foot is dependent and inactive too long at a time Awareness of the first symptoms is sometimes lessened by preoccupation at a desk, but in many instances the discomfort results almost instinctively in elevation of the feet Frequently the feet are elevated on a desk or chair but the surroundings may make this undesirable A footstool will be found useful

Running is a normal exercise that will help develop the foot and rarely causes strain Ascending and descending stairs is more liable to strain the heart than the foot Children frequently jump and skip rope to the point of strain An environment in which normal exercise can easily be carried out is ideal for children In large cities however where functional demands are altered as soon as the child begins to walk early hygienic measures are necessary and the problem of obtaining adequate exercise is increased The demand is met t[illegible] me extent by playgrounds and parks as well as by Scout activi[illegible] and the like Swimming is a particularly valuable exercise for th[illegible] t especially for the weak foot since it does not require

weight bearing it cannot however substitute entirely for normal walking.

The normal function of the skin is best protected by frequent bathing followed by thorough drying Ordinary soap and water is the best antiseptic A nail brush with bristles that are not too stiff may be used. An orange stick serves to cleanse under the edges of the nails no sharp instruments should be used for fear of breaking the skin If there is a tendency toward perspiration or vascular dilatation it is well to finish the foot bath with cold water After drying talcum powder should be dusted on the feet to assure removal of moisture, and into the shoe to decrease friction rub

The nails should be trimmed with a cavity in the center, unlike the shape of the finger nails This concavity is easily made with a curved scissors the resultant points of the margins are cut straight.

Abnormalities such as blisters corns or calluses should receive immediate care and the underlying cause should be removed Skin abrasions should be washed thoroughly with soap and water and covered with a sterile dressing

The hygienic care of the foot is closely associated with the prophylaxis of foot disorders The principal prophylaxis occurs in children for which we need an understanding of the growing child s foot.

THE FOOT OF THE GROWING CHILD

The care of the foot from early childhood should receive some attention from the physician upon whom rests the responsibility of protecting the child against disturbances in growth He needs to be able to assure the parents that a child s foot is normal when the alteration which they have observed is within the range of physiologic change At the same time his ability to recognize abnormal deviations promptly will act as a prophylactic measure, in many instances against serious trouble

The presence of a longitudinal arch in the newborn child was doubted for many years but has now been established. Frequently a fat pad disguises it and the short muscles on the plantar surface sometimes develop to fill in the space normally taken up by the longitudinal arch Footprints of a newborn child may indicate the absence of a longitudinal arch because the pressure exerted is greater than the child s body weight This forces the foot into a pronated position and the imprint indicates flatfoot When the imprint is taken with the foot in the normal position and pressure equivalent

to the body weight is exerted, the presence of an arch is eviden (Fig 24)

The position of the foot in the child differs from that in the adul in its relationship to the lower extremity In the early stages there i some degree of retention of the internal rotation of the leg Asso ciated with this internal rotation there is often a residue of adduc tion of the foot. The adduction of the forepart of the foot is extreme in the intra uterine stage, but gradually decreases In the newborn

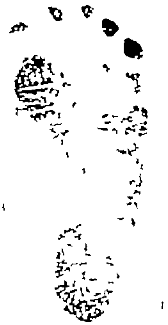


Fig 24 Imprint of the foot of a newborn taken with counter pressure equal to the body weight

and even for a time after birth it is retained to some degree The resultant effect of these two positions is an intoeing which is com monly seen in growing children

A certain degree of intoeing therefore is normal However this should gradually disappear so that at least by the end of the fourth or fifth year the foot and leg should normally have the same re lation hip as in the adult It is important to recognize the degree of adduction that still might be considered within the range of nor mal [illegible] an abnormal amount of adduction constitutes a deform ity kn[illegible] pes adductus In a similar way the foot which was in ex[illegible] upination in utero may retain some degree of supination even [illegible] th and still be normal A high degree of this supination

however particularly if it persists after the third year must be considered a deformity namely pes supinatus

Pes supinatus and pes adductus are frequently not recognized The earlier they are noted and treatment instituted, the better the prognosis The technic of treatment for these deformities will be considered separately The period of normal persistence of supination and adduction can be shortened if it is recognized and conservative treatment is provided These deformities will correct themselves barring any unusual interference, with the assumption of normal function The treatment therefore of the normal supination and adduction of early childhood is to permit the child to carry out normal function when he is ready to do so

The first use the infant makes of his feet is to kick and twist them and wiggle his toes Freedom of the extremities is necessary for development. Later it is natural for the child to crawl and in this stage he develops muscles which will be used in the future for standing and walking

The infant requires no shoe at all or only a soft shoe for protection against cold and as a hygienic measure This shoe should be loosely fitted and of soft material No structure should enclose the rapidly growing foot in such a way as to interfere with growth and no shoe should be so firm that the toes and muscles cannot contract as freely as they like

When the child begins to walk, a shoe is necessary for protection since he usually must learn to walk on hard floors and will be required to walk on hard surfaces The shoe must have a sole thick enough to protect against these surfaces, but at the same time pliable enough to permit adequate use of the foot. A stiff-shanked shoe will make normal walking more difficult it will hinder the contraction of the small plantar muscles and retard development of the foot It is important that the shoe shall in no way interfere with the development and normal use of the foot The child may stand on its bed and other soft surfaces without shoes

Standing and walking should not be urged until the child is ready to do so voluntarily The pride of the parents should not influence the time at which the baby takes its first steps Experience has shown that he himself is the best judge of when he is ready to stand and walk. There is a variation in the ages at which normal children start to walk, and several factors decree the optimum time Important among these are the strength of the structures the weight of the child and the development of equilibrium and confidence Some children require a longer period of training than others

There is rarely any need for interference by means of the mechanical devices that promote early weight bearing. All exercises that increase strength without making an undue demand can be recommended safely. The best of these are the ones which are accomplished in ordinary play.

The development of gait seems to be an instinctive procedure that requires no particular training. At first the child will walk for only a short distance, rest, and then try again. In this way he practices frequently and yet avoids strain. The child first walks with a waddling gait. The legs are wide apart to give a broader base and more stability. The feet are gradually used as organs of propulsion. They are slightly everted. The two-year-old usually has some genu valgum, a tendency to pronation, and an uncertain gait. He falls frequently. There is also some valgus present at the ankle, a condition nearly always associated with pronation of the foot.

The genu valgum and valgoplanus of the foot are not always present at the age of two years. This stage occurs later in some children. The position of the foot and ankle is not dependent on the age, but is due to the fact that the structures of the foot and leg are not developed sufficiently to carry out their normal function. In other words, this is a "static" alteration. Since these changes in position are due to a functional decompensation, there is, as could be expected, a variation in the age at which they may develop in children. At two years of age there is usually a period of rapid growth. This period varies in different children, and there is also a difference between the sexes. In periods of rapid growth the size of the child sometimes increases faster than the strength of the structures. The genu valgum and pes valgoplanus are expressions of this decompensation. As the strength increases, the structures are able to carry out the normal demands, the decompensation is lost, and the valgus at the knee and ankle disappears. The pronation of the foot is lost and the arch is reestablished. This apparently natural correction of these alterations has led to the expression of "out-growing" static alterations.

It is difficult to draw a line between variations that could be considered normal and variations that must be considered deformities. It might be well to think of these alterations as a result of prolonged strain. They are important enough to require medical attention and should be recognized in their incipient stage.

During this period of rapid growth the child should be protected from strain by means of periodic rest. Exercises should be carried out to increase his strength. The use of vitamins, calcium and sun

shine, in other words an antirachitic regimen is recommended as a valuable adjunct in the treatment of functional decompensation in children It is interesting to observe in the development of the normal child how frequently he will lie down in the midst of play in order to take a short rest and then get up and carry on with his activities *This is probably the best form of protection against de compensation* A child may become so intent on his activity that he is carried past the desire for such rest, and for this reason will have a tendency toward fatigue. Such a child may require a decrease in the stimulating activities and some guidance with regard to proper rest. With practice there is a gradual improvement in the type of gait and in the statics of the foot, ankle and knee

At five years of age growth should be such that the limbs are straight. The center of gravity should come through approximately *the middle of the knee, and the heel should be in the midposition or* even in slight varus The longitudinal arch should be evident, and the foot should have an appearance approaching that of the nor mal adult.

If the pes adductus position supination or genu valgum and pes valgoplanus are retained, they must be considered abnormal It must be stressed that not all intoeing is due to an adduction de *formity* or to an inward rotation of the tibia If the foot is weak and there is a functional decompensation the foot tends to assume a valgoplanus position At the same time there is a tendency to walk with the foot externally rotated, thus the flatfooted gait. A child will frequently try automatically to compensate for the strain and correct the deformity by walking on the outer side of his foot with the foot in adduction Frequently the child that is brought for consultation on account of intoeing reveals a weak foot with pes valgoplanus With correction of the pes valgoplanus the intoeing disappears *In my experience the greatest percentage of intoeing* is an automatic adjustment on the part of the child to foot strain

Supination will not be recognized while the foot is in a weight bearing position it must be suspended in the air As soon as weight is placed on the foot with a supination deformity, the foot will have the appearance of a pes valgoplanus because the medial surface of the anterior part of the foot will come in contact with the floor It can accomplish this only if the tarsal area goes into pronation and the heel into valgus In other words pronation and valgus might be considered compensatory alterations to accomplish weight bear ing in case of supination of the forepart of the foot

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fancy must be regarded as deformities if they still exist at the age of five. It is a matter of judgment on the part of the physician whether or not the position of the foot conforms to that of a normal child of the same age. *The rules for position are to some extent arbitrary* inasmuch as there are periods of rapid growth that may not only show retention of the altered position but may even increase the alteration beyond the degree that might be considered normal If this rapid growth is present, the significance of the condition would not be so formidable as if the condition existed without it. This would hold true, however if there were an acute illness or dietary insufficiency to account for the altered position Rickets, too would cause a similar condition but this must be considered a separate entity Just where to draw the line between alterations within the limits of normal and true deformities is a matter of degree and depends on the judgment of the clinician

The chief need for distinguishing between a so-called functional deformity and a structural deformity or in other words between an alteration within the range of normal and a true deformity, is in the treatment. With a functional deformity it is sufficient to remember that if the foot can be used in a normal way it will adjust itself to normal function and gradually reestablish its anatomic relationships In the true deformity the foot can no longer be used to carry out its normal function unless some correction is first obtained. *More and more I recommend that any alteration of position should be corrected as a prophylactic measure against the possibility of its developing into a deformity*

SHOES

Children s Shoes. The infant s shoe should in no way confine the foot It should be of soft material such as a fine kid with a soft sole or the infant may wear no shoe at all.

The shoe for the growing child should have a straight inner margin adequate toe space, a low heel and a thick, pliable leather sole the upper part and particularly the toe, should be of tough leather to withstand scuffing The cost of such a shoe should not be exorbitant The shoe should be fitted so that there is plenty of room for the toes and at the time of purchase the rapidity of the child s growth should be considered in selecting the size. When the foot is growing rapidly it is well to allow for such growth This shoe is for the normal foot. If there is a structural weakness and some correction is necessary no warning can be too strong to advise

against the continuous use of the stiff shanked shoe, which ultimately increases the disorder since it prevents normal use of the foot.

Men's Shoes The shoe should fit properly and allow sufficient room for the toes The leather sole should be thick enough to assure protection against hard walking surfaces and at the same time permit the normal rolling gait.

The shoe I have chosen for the normal foot has a sole 5/16 inch thick from the toe to the heel, at the heel it is compacted so that it is 1/4 inch thick. The heel is 1 inch high Leather is used not only because it is tough but because it has pliability and yet gives support (Fig 25)

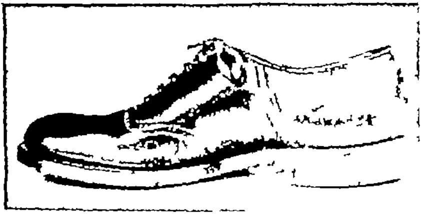


Fig 25 Man's shoe which meets the author's requirements

The shank should be broad to provide support It may contain a metal light enough to give additional support but flexible enough not to interfere with normal gait The heavy rigid steel shank found in many shoes is absolutely contraindicated for the normal foot

A heel simplifies the rolling gait and provides protection when the foot strikes hard surfaces For this reason and also because it is more quiet the rubber heel has an advantage over the leather heel. More recently a composition insert which wears better than leather has been used. With correct gait, the foot strikes in front of the body with no superimposing body weight the amount of jar received from the heel is minimal in any case, whether the heel is of leather rubber or composition

The sole of the shoe should be straight on the inner side to allow the great toe free mobility without pressure An exaggerated inward curve of the lateral part of the shoe cramps the outer toes The shoe with a pointed toe needs no further words of censure The upper

of the shoe should be roomier in the region of the large toe than in the region of the small toe.

The leather in the region of the tarsal area should fit smoothly so that the strip that comes under the longitudinal arch will be drawn up snugly when the shoe is laced. At the same time there would be a shaping of the leather on the dorsum of the foot to allow adequate space for the prominence in the region of the first cuneiform and navicular bones

The posterior part of the heel should be shaped to conform to the curve of the calcaneus so that, when the shoe is laced there is no gaping at the upper margin



Fig. 26 Woman's shoe which meets the author's requirements

The low shoe is preferable, since the ankle has more freedom and also since it allows the foot better ventilation which is important The high shoe is worn by those who need protection around the ankle.

The leather should be pliable and at the same time able to withstand wear For the normal foot there is no need for vici kid the objections to soft leather are that it peels and does not wear so well or keep its appearance so well as regular fine calf leather

Women's Shoes. The question of the best shoe for women brings up the problem of what the normal functional demands are for the foot of the modern woman Certainly appearance is a consideration but the demands are extremely variable The needs of the modern woman include walking shopping, going to the theater and to teas, dancing and taking part in sports These demands are so divergent that no one shoe can meet all of them adequately The solution lies in having different shoes for different occasions Certain fundamental rules will hold for all types of shoes

First of all normal walking is carried out best in a shoe which corresponds closely to the man's shoe. The upper can be modified in such a way that it will suit the demands of style. This would make it a so-called "sport" shoe. The question whether the shoe can be rubber soled depends on whether it is to be used on hard surfaces. If the hiking is done on soft ground such as in the woods or on a golf course, a heavy rubber sole or a composition sole may be used. If the walking is to be done on hard surfaces a leather soled shoe is necessary to assure protection. For the woman's walking shoe I use one with a sole ¼ inch thick and a heel 1 inch high (Fig. 26).

The shoe for shopping has entirely different requirements. Here the demand is for a shoe suitable for prolonged standing on hard



Fig. 27. Woman's street shoe.

surfaces and at the same time it must have more style. To accomplish this with a minimum of functional impairment in the walking that is to be done, a shoe of special design is necessary: the inner side of the shoe is quite straight, the toe is raised, the sole is $\frac{3}{16}$ inch thick, and the leather under the arch is thinner and has a steel support. The heel should be about 1¾ inches in height (Fig. 27). The advantages of such a shoe are that it gives support in standing, while at the same time it is light in weight, the appearance is appropriate, and it may be had in different colors and materials to go with various costumes. The increased height of the heel has the advantage of decreasing the demand made upon the muscles of the foot and leg. The angulation and position of the foot in themselves decrease the functional demand; furthermore, less force is required in walking with a higher heel. The shank, which is reinforced with steel, fits well up under the longitudinal arch and gives additional support.

This shank is broad (1⅝ inches wide) and the steel and leather are quite pliable. The sole is thick enough to give protection and at the same time pliable enough to permit some degree of rolling gait

This shoe cannot replace the walking shoe and be worn at all times because there is not a normal functional demand on the foot. The foot would gradually lose some of its strength and be subject to overstrain and resultant disorders

The shoe for dancing may have a high heel the broader the heel surface, however the better from the standpoint of support The shank should be firm and broad enough to support the wearer The sole should have enough leather so that the floor is not felt any more than is necessary The upper can be any style or material desired the toes may be free as in the present day dress shoe. Dancing is done mostly on the toes the only serious objection to this type of high heel is that it forces a bad distribution of weight putting too much strain on the anterior part of the foot Fortunately the style of the moment has made possible the wearing of the low heeled sandal with a broad-surfaced heel *The low heeled sandal* with its many variations in style, fulfills the need for so-called spectator sports wear afternoon teas theater parties and dancing much better than any type of shoe that has previously been designed

So far only the best shoes for the normal foot have been described Corrective shoes will be discussed under the various headings where their use is indicated So-called orthopedic shoes are usually stiff shanked the objections to this type of shoe for the normal foot have already been discussed

In my experience I have found that it is so difficult for patients to choose proper shoes that the responsibility rests with me as to whether a given shoe is satisfactory Many of the local salesmen have become educated to the fact that shoes must be fitted properly in order to meet with my approval They never attempt to sell a wrong size simply because the right size is not in stock This has gradually led to a situation wherein in most cases the shoe sold to the patient is entirely satisfactory Nevertheless each shoe must be checked for proper fit if any responsibility is to be assumed

Fitting Shoes. To fit shoes the patient is asked to stand with the weight evenly distributed on both feet The anterior part of the shoe is examined first If the upper projects over the sole this can be observed readily Then the heads of the first and fifth metatarsal bones are palpated to see if there is too much tension on the leather at these points Next the position of the distal ends of the first and second toes is ascertained either by pressure or by making

the patient force the toes up against the dorsum of the shoe, showing where the toes end in the shoe. The shoe is examined at the heel to see if it clings properly, and the upper margin of the shoe is observed to see if there is any gaping Frequently one foot is larger than the other, either broader or longer or both In such cases the larger foot must always be fitted If the difference is great, which will occur only in a true abnormality the sizes may have to be broken

For the normal foot these conditions must be fulfilled in every particular In practice, however the normal foot is rarely encountered, and the problem is to fit the abnormal foot, which means that allowances must be made The first condition is that the anterior part of the foot be fitted *The adjustment of the loose heel is a* secondary condition This must be corrected by means of felt lining celluloid heel cuff or if the looseness is great, by having the heel taken in

TRAINING IN WALKING AND STANDING

Frequently the physician is consulted, particularly with regard to children, as to the proper way to stand and the correct way to walk Much that has been written is false, and incorrect training in dancing schools has sometimes resulted in disorders of the feet. The training of children in schools is a significant and important problem, particularly to school nurses and physical education departments There is a definite need for the establishment of a normal gait as well as normal posture.

There are certain fundamental requirements for normal gait, but individual variations must be recognized as still within the limits of normal. A fundamental point about standing correctly is that good posture is not purely a matter of the feet It is a question of muscle balance and transmission of body weight through the optimum line of carriage In other words, the center of gravity must come through the bony structure of the body in such a way as to cause the least strain The mechanics alone involved in this complicated problem are sufficient to baffle a physicist, since a single joint has many possible mechanical positions that are still within normal, and each muscle acting at that joint has a stress and pull that is variable to an immeasurable extent. The muscles are controlled by the nerves and these nerves work on a reflex basis so that the problem becomes complicated if it is traced to its ultimate scientific explanation It is, furthermore a dangerous procedure to attempt analysis of any one of the joints and then apply the conclusions in a practical application The chances are that this would

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Fitting Shoes. To fit shoes, the patient is asked to stand with the weight evenly distributed on both feet. The anterior part of the shoe is examined first If the upper projects over the sole, this can be observed readily Then the heads of the first and fifth metatarsal bones are palpated to see if there is too much tension on the leather at these points Next the position of the distal ends of the first and second toes is ascertained either by pressure or by making

interest to notice the beautiful feet of such people; they are attractive, and their trimness expresses functional capacity (Fig 28) These observations have led to a method of teaching correct stance and correct posture by means of a sandbag, 7 inches square and 2 inches thick. It is filled with sand or, preferably two bags of bird gravel, since this is cleaner and easier to obtain in a large city The weight comes to about 4 pounds Heavier bags may be used for adults and lighter ones for children, but in general one bag will serve the purpose satisfactorily

The patient is taught to hold himself as tall as possible and to balance the sandbag on his head This of necessity makes for the best posture possible, and one obtains the optimum position for function Any extra weight balanced on the head will require coordination of all the structures that carry such a load It is possible to balance a small sandbag by means of the neck muscles alone, but the person is taught to make the weight of the sandbag come through the center of gravity of the trunk as well Full coordination of all the structures of the body in balancing the extra weight on the head will result in the optimum position for function and thus the best posture.

Anyone who stands for a great length of time, however, requires a change of position occasionally No matter how good the position if it is held for a long time, the muscles will tire. This change may have many forms and one of its objectives is to place less strain on certain muscles in order to give them a chance to recover from fatigue. It is so instinctive as to be automatic; at the same time, however it should be borne in mind that the person should return to the normal upright position from time to time so that it becomes habitual

The three phases that apply to posture of the back and posture in general apply to the feet. There is the relaxed position wherein most of the strain comes on the articulations and ligaments there is the position of tension and finally there is the habitual mid position The relaxed position is attained when a person is standing completely relaxed military posture is obtained by having him make himself as tall as possible; while normal position is attained by balancing a sandbag on the head as described

The position of the feet under these circumstances varies The relaxed position permits some valgus at the heel, pronation of the tarsal area and increase in spread of the anterior part of the foot The position of tension is one in which the heel is drawn over into varus and the foot is drawn into supination at the tarsal area

lead to error inasmuch as the conclusions are drawn from but one factor whereas a consideration of all the factors would be necessary before a normal relationship of all the structures to each other could be established.

The attempts to establish these relationships on a scientific basis are commendable, and the research work along this line is impor

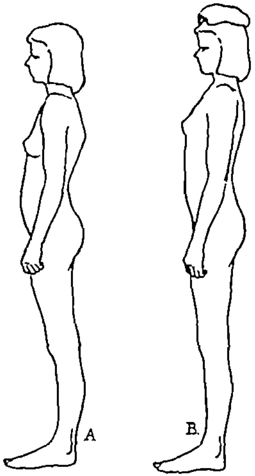


Fig. 28 A. poor posture as seen on first examination B immediate improvement with the application of the sandbag

tant The only error is to draw conclusions which apply for the whole body on fragmentary studies made on but one of the elements involved For the present, a more practical approach is necessary

The best posture has been observed in people who carry burdens on their heads as on the Island of Bali for example This holds not only for the position of the head neck and trunk, but also for that of the legs and feet and for posture in general It is of peculiar

advisable that the patient be informed that each foot should stay on its own side of the line

The best method for teaching gait is imitation The preceptor should be able to execute the normal gait and then ask the patient to imitate it. In addition, the person being taught should be permitted to walk, and his gait may then be imitated so that he can see it. The faults may be exaggerated The preceptor then demonstrates correct posture and exaggerates certain phases of normal walking in order to emphasize them The patient is instructed to practice what he has been taught and to return after a definite period for observation. The improvement in gait is then noted, and faults that have persisted are corrected

Once normal gait has been attained, there is usually no need for further instruction, the exception being the person who for some reason acquires some abnormality or disturbance in function The teaching of gait is essential in reeducation from abnormal gait In other words if there is a pathologic condition which does not permit normal gait, and this is removed by surgical treatment it will still be necessary to teach normal gait. I have carried this concept even further, particularly with regard to all static deformities. Since static deformity is the result of a disturbance in function it should follow that correction of the function to normal will reestablish normal anatomic relationships, and this has been proved to be true. Pes valgoplanus, for instance, can be corrected by reestablishment of normal function The mechanism by which this is executed now leads us to the subject of orthopedics of the foot

to such an extent that the base of the first metatarsal bone scarcely touches the ground while the muscles of the foot and leg are contracted. The normal habitual position is one in which the heel is in the midposition or in slight varus and the anterior part of the foot rests with weight on the head of the first metatarsal bone and on the external side of the foot and a lesser amount of weight bearing on the heads of the three middle metatarsal bones. The toes are contracted sufficiently to rest on the ground. The longitudinal arch is slightly lower than that without weight bearing but is recognized easily.

Good general posture is also required for walking. The gait of choice is one that will ultimately require the least effort and at the same time be the most graceful. This is a natural gait in children but is retained only under normal conditions. It must be remembered that the child does not obtain the optimum gait immediately on walking. On the contrary, learning to walk is relatively difficult. The base formed by the feet is wide, there is a great deal of uncertainty, and the coordination is primitive, but with practice this gradually improves, and with improvement in gait the anatomic changes previously described take place. If for some reason normal gait is not acquired, then the anatomic development will be retarded and some residue of the infantile changes will persist, so that a deformity may be the result of impaired function. This negates the opinion that a deformity is always the cause of alteration of function, since here functional alterations may cause the anatomic changes. At the age of four or five years the gait should be normal.

Under normal conditions walking consists in a light or rolling gait. This means that the heel strikes the ground first on the outer side; the weight is then transmitted over to the inner side, across the heads of the metatarsal bones onto the head of the first metatarsal bone, and is finally propelled over the toes, particularly the great toe. The motion is screwlike, coming from the outside and running forward and medial to the great toe. The weight of the body is taken up from the heel to the toe, and as the weight is carried on the anterior part of one foot the other foot swings through the air in a brief phase to place the heel again on the ground and repeat the same procedure. The foot turns neither out nor in but goes straight ahead. The legs should not be permitted to cross in front of each other, nor should the distance between the malleoli be too great; in other words, the sailor's type of gait is avoided. Gait is commonly taught by walking a line, but it is

advisable that the patient be informed that each foot should stay on its own side of the line

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PES VALGOPLANUS

(*Flatfoot*)

Flatfoot" is a lay term which describes the appearance of the foot in a pes valgoplanus position Pes valgoplanus is a structural de

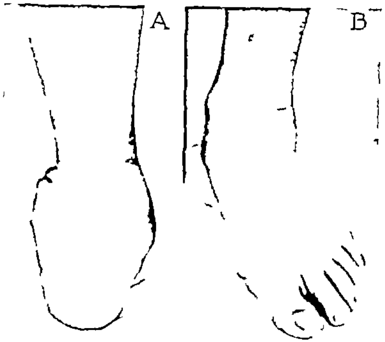


Fig 29 *A* Valgus position of the heel *B* planus of the foot associated with valgus of the heel

formity which may arise from several causes Typical of the condition is the outward rotation of the calcaneus with regard to the weight bearing line of the leg Associated with this valgus deformity of the heel is a pronation deformity which causes the head of the talus and the navicular and first cuneiform bones to be displaced medially

and downward This results in a lowering of the medial longitudinal arch (Fig 29) The anterior part of the foot is not only pronated, but also abducted The foot is thus in an everted position Owing to counter pressure from the floor, the head of the first metatarsal bone is displaced dorsally

This deformity may be congenital or may be acquired The ac quired form may develop as a result of a functional decompensation of the foot so-called static pes valgoplanus" as the result of trauma or secondary to paralysis Thus pes valgoplanus can be classified on an etiologic basis as congenital static traumatic or as para lytic

STATIC PES VALGOPLANUS

Static pes valgoplanus is the most common of all foot ailments and is by far the most important clinically It occurs in early child hood and during adolescence but is most frequently present in adult life. In its prodromal stage it is described clinically as a weak foot This is an acutely painful condition without deformity and is the result of a functional decompensation When an acute strain arises in the presence of a pes valgoplanus reflex muscle spasm will occur and the condition known clinically as spasmodic pes valgoplanus is present. If a pes valgoplanus has been present for a great many years particularly in older people, the alterations in the articulations are such that the foot has a tendency to become fixed and a condi tion arises which is described clinically as 'rigid pes valgoplanus

Etiology The mechanical development of static pes valgoplanus is an alteration in anatomic position as the result of an imbalance between the capacity of the foot and the demand made upon it This imbalance can be called a functional insufficiency" or a "functional decompensation of the foot Normal functional ca pacity depends upon the strength of the structures as well as upon the size of the load which the foot has to sustain Any increase in the load beyond normal, or any decrease in the functional capacity of the foot below normal will result in a decompensation

Common factors which increase the load and cause the disorder are excessive weight rapid growth and prolonged standing Factors that decrease the strength of the structures are those that involve the bone, such as rickets and osteomalacia those that involve the ligaments such as stretching or tearing by trauma and those that involve the muscles such as disuse, strain malnutrition and infec tion The altered position of the foot and fatigue from various causes also act to decrease its functional capacity The new position does

not permit the most efficient execution of normal activity so that the greater the deformity the greater the interference in function The relationship of the bones to each other and the transmission of weight bearing under normal conditions have been described under correct walking and standing.

Pathogenesis. The relationship of the bones in the foot to each other is altered at the talocalcaneal articulation in the presence of a decompensation regardless of the etiologic factors The calcaneus rotates outwardly in a valgus position with respect to the talus At the same time there is an alteration at the talonavicular articulation The talus rotates inwardly in an oblique axis and the head is forced medially and downward. As the head of the talus is depressed pressure is also brought against the sustentaculum tali which is lowered, and the anterior part of the calcaneus is forced downward The deltoid ligament is stretched, at times to such a degree that there is a subluxation at the talonavicular articulation. The altered position of the calcaneus, owing to the anterior depression and the valgus position at the talocalcaneal articulation causes an altered relationship between the calcaneus and the cuboid. The cuboid is lowered and forced laterally No articulation acts independently all are related to one another A displacement of one bone will ultimately result in an altered position of another The deformities thus far caused by the functional decompensation are valgus of the calcaneus and pronation of the tarsal bones with a resultant lowering of the mediolongitudinal arch

Owing to the fact that counter pressure from the floor occurs at the head of the first metatarsal bone, this bone is displaced dorsally and the anterior part of the foot is forced into an abducted position with respect to the heel. Force is exerted in a lateral and dorsal direction Normally this is transmitted through the shaft of the first metatarsal bone to the first cuneiform and navicular bones Pressure transmitted through the shaft is equal to the component of the forces caused by the body load transmitted through the head of the talus The forces meet at the navicular bone If there is a decompensation the navicular bone is usually depressed and forced medially The prominence thus formed on the medial side of the foot is frequently a presenting complaint.

The cuneiform bone is higher than the adjacent navicular bone and projects on the dorsum of the foot At times the cuneiform bones become depressed and the proximal end of the first metatarsal bone projects up over the adjoining end of the surface of the first cuneiform bone The weight transmitted through the cuboid

is countered by pressure from the floor transmitted through the fifth metatarsal bone.

A functional decompensation in this area will cause a dorsal and lateral displacement of the distal end of the fifth metatarsal bone. Excessive force in the posterior part of the foot results in valgus and pronation Counter pressure from the floor forces the medial side of the anterior part of the foot dorsally

To summarize, then the following changes occur

1 The calcaneus is forced into valgus position at the talocalcaneal articulation and its anterior part is depressed

2 The talus rotates to force the head medially and downward.

3 The navicular bone is displaced medially and depressed in a plantar direction

4 The medial cuneiform bones may sink and go into pronation.

5 The cuboid bone is lowered and forced outward.

6 There is a dorsal displacement of the first metatarsal bone.

7 These changes result in a loss of the longitudinal arch

8 The anterior part of the foot is abducted

9 The fifth metatarsal bone is displaced laterally and dorsally

10 Dorsal displacement of the first and fifth metatarsal bones causes obliteration of the transverse arch (Fig 30)

During the period of alteration in position of the foot, strain is placed upon the ligaments and they become irritated and inflamed causing pain In the same way, undue pressure is exerted on part of the articular surfaces whereas other parts are not subjected to pressure. The pressure may be so great as to set up an inflammation of the articulation An inflammatory reaction either articular or periarticular, frequently causes a reflex muscle spasm If the altered position is held for a prolonged period, the ligaments become fixed in the new position on one side they are stretched and on the opposing side contracted Ultimately compensation is established even though the foot is in valgoplanus Prolonged irritation of the articulations produces arthritic reactions—denudation of the articular surfaces with overgrowth of the margins

So far the mechanical changes caused by the functional insufficiency have been explained with regard to the forces acting on the bones joints and ligaments The mechanics of the foot are equally dependent upon the action of the muscles It is the function of the muscles to bring and hold the foot in the optimum position for weight bearing This requires a muscular balance which depends not only on the size and strength of the muscles, but also upon the mechanics involved in the foot such as leverage and gravity

The balance of the muscle groups may be altered owing to weakness in a group of muscles. Once a high degree of deformity has occurred the position of the otherwise normal muscle may be altered decreasing its effectiveness and thus increasing the deform



Fig. 50 Roentgenograms of pes valgoplanus A, Without weight bearing; B with weight bearing. Note the lowering of the head of the talus and the navicular

ity. The altered position of muscular attachments as a result of the pes valgoplanus deformity will influence muscle balance. For instance, if the great toe is in extreme valgus the extensor hallucis longus will act as an adductor as well as an extensor

Another alteration encountered in the muscles of the foot is a shortened calcaneal tendon because the posterior part of the cal

caneus rises when the anterior part is depressed and at the same time the valgus position of the calcaneus increases the shortening and makes the posterior group act as an everter of the heel The flexor hallucis longus is under tension

In a highly developed pes valgoplanus the great toe is displaced dorsally, and there is an increased loss in function of the flexor hallucis longus The tibialis anterior raises the inner margin of the foot, and is more important in walking than in standing The tibialis posterior acts as an adductor of the foot.

Normally there is a functional balance between the muscles of the foot during standing and walking but if the foot is in a valgoplanus position, the muscles are in imbalance and the everters are stronger than the inverters thus tending to increase the deformity Also of importance in retaining the normal position of the foot are the small plantar muscles With the lowering of the arch and the lengthening of the foot these muscles are stretched Since they can no longer carry out their normal function, they may show disuse atrophy In the same way a stretch is placed upon the plantar aponeurosis It can therefore be seen that the mechanical changes that occur in the foot depend upon the function of the muscles At the same time the function of the muscles can be altered as a result of the mechanical changes present in the valgopronated foot.

Static pes valgoplanus is therefore a functional decompensation The anatomic changes in the relationship of the bones to each other cause a lowering of the medial and lateral longitudinal arches and of the transverse arch The articulations are under strain with an alteration of the ligaments The occurrence of the deformity depends upon the action of the muscles Muscle action is altered in the presence of a deformity The pathogenesis of static pes valgoplanus is complicated, but follows a definite pattern The etiologic factors that can cause a functional decompensation are many and varied and depend upon the age of the patient.

Static pes valgoplanus may therefore, be classified clinically as static flatfoot of childhood static flatfoot of adolescence, and static flatfoot of the adult.

Static Pes Valgoplanus in Childhood. *Etiology* Pes valgoplanus frequently occurs in childhood as a result of retardation of development but more often is the result of a decompensation in function In early childhood the factors that bring about such a decompensation are primarily the underdeveloped structures For the most part the skeleton is still in cartilage. The muscles and ligaments are too weak to hold the normal position on weight bearing The develop-

ment of these structures occurs from the time the infant starts to kick and continues through the crawling stage until the first steps are taken If for some reason the normal use of the limbs in simple kicking and crawling is not permitted the development of the structures will be hindered. Such a delay in development will be a factor in causing pes valgoplanus If the child is encouraged or forced to stand and walk before the structures are ready, then the overload on the underdeveloped structures will encourage pes valgoplanus A nutritional disturbance will act as another causative factor poor nutrition can cause impaired muscle tone and a dietary deficiency

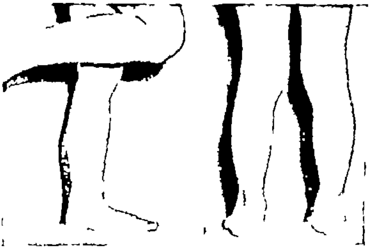


Fig 31 Pes valgoplanus in childhood with valgus of the heels and genu valgum

will cause softening of the osseous structures Overweight will cause a strain

As already pointed out the foot normally shows a loss of arch during the stage of first weight bearing It is not wise to combat this normal position of the foot by the use of a support whether it be by a stiff shanked shoe or a steel arch support since such supportive measures will interfere with development and be a causative factor in establishing a true pes valgoplanus Shoes can further be a factor in the condition if they are too tight since the toes may be so cramped as to prevent normal development Infectious diseases are a causative factor in static flatfoot because there are more structural weaknesses in these and similar illnesses

Symptoms The symptoms of pes valgoplanus in childhood are delayed walking lack of desire to walk and fatigue Pain may be present in the leg and cause a limp The pain may be in the foot

knee or, occasionally in the hip Muscle cramps in the legs may awaken the child during the night. There is interference with the child's ability to play If walking is forced the limp becomes more noticeable.

Examination shows a valgus at the heel which is frequently associated with the genu valgum (Fig 31) There is pronation in the tarsal area and the great toe is rotated so that the medial side approaches the floor The head of the talus can be felt protruding in the soft tissues. Usually it does not touch the floor The fat pad under the longitudinal arch may persist, depending on the age of the child and the muscles can be felt filling the space of the longitudinal arch The child walks with the feet externally rotated, and the forepart of the foot is abducted. The legs are apart so that the base is wide, increasing stability

If the condition is not of long standing, the child has an almost instinctive tendency to correct the deformity This is done by rotating the foot inwardly and by bringing the anterior part of it into adduction with a tendency toward a rolling type of gait. The occurrence of this intoeing in the presence of a foot that shows some valgus and pronation must be interpreted as a natural attempt at correction it will disappear on treatment of the pes valgoplanus

Conservative Treatment Prophylactic treatment consists primarily in promoting the normal development of the foot. Any shoe that interferes with this development is contraindicated. The proper shoe for children is described on page 40 In the summer the child should be permitted to go barefoot on soft ground lawns and beaches If desirable, the child may also go barefoot on the rugs indoors

In the treatment of valgus or valgus and pronation, the predisposing factors should be eliminated

Correction of the deformity is based on the pathogenesis Since the calcaneus is in valgus position the heel must be brought into slight varus or the normal position To accomplish this, the heel of the shoe is raised ⅛ to ¼ inch on the inner side, depending on the severity of the deformity and the age of the child When genu valgum is present the greater correction is used This correction plus the prophylactic treatment may be sufficient to remedy the condition

To be sure that the child will walk with the normal gait the use of an anterior bar on the shoe offers definite aid I have devised an anterior bar which is comma shaped and is attached to the shoe immediately posterior to the heads of the first second third and

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fourth metatarsal bones This bar has an inclined plane, and slopes from the outer to the inner side with a difference in height from ⅛ to ⅜ inch (Fig 32) The amount of correction is graded The initial correction depends on the severity of the deformity, and the amount of correction taken is increased as rapidly as the patient can tolerate it That part of the bar posterior to the second third and fourth metatarsal bones is broader and higher than the section posterior to the head of the first metatarsal bone. In this way pressure

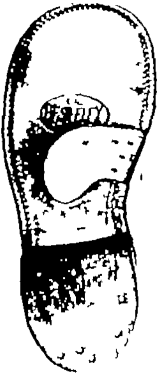


Fig. 32 Child's shoe corrected with a Hauser bar

is applied to the hollow part of the foot posterior to the heads of the middle metatarsal bones The supinating effect of the raised heel is counteracted by the bar for the anterior part of the foot which is brought into pronation In walking therefore, the heel is held in varus the weight goes through the outer side of the foot and the bar transfers the weight medially so that it is lifted off the floor by means of the great toe aided by the other toes The effect is normal heel-and toe walking which the child assumes without any further instruction The use of the normal gait with the foot in proper position assures correct development of the foot

The application of this treatment is practical and has met with

unqualified success Symptoms are relieved at once the normal gait becomes habitual in a few weeks, and the appearance of the foot improves so that the arch becomes apparent and is sustained with weight bearing Protection against recurrence is assured as long as normal gait is retained

No artificial exercises are utilized in this treatment The principle of functional exercise is used The child *is encouraged to carry out* normal exercises walking, running, riding a tricycle, or pushing a scooter Strain is guarded against by the use of repeated rest periods The child usually rests instinctively when tired, only the excitement of play or encouragement from an adult stimulates him to a point of strain

The use of artificial exercises, such as picking up marbles with the toes or putting a marble in the shoe under the arch to make the child supinate his foot has not been found practical The controlled use of graduated functional exercise is therefore advocated

Operative Treatment Since the inauguration of the conservative treatment just described operative procedures are only rarely considered necessary in children

Operations for the treatment of pes valgoplanus are transplantation of muscles operations on the ligaments, including periosteal grafts and operations on bone, particularly fusions and osteotomies Operations on the muscles alone without correction of the foot, are rarely satisfactory

Some surgeons have taken a free periosteal transplant from the tibia or permitted the transplant to remain attached and fastened it to the denuded surface running it from the tibia to the navicular bone on the medial and lower surfaces holding the talus and the navicular in place Arthrodesis of the talonavicular articulation has been performed after reduction of the subluxation, the capsule is shortened and the tibialis posterior tendon is transplanted posteriorly and fastened to the navicular In these cases it was reported that the correction persisted although the arthrodesis ultimately was lost

In another operation with the foot held in the overcorrected position the internal and middle cuneiform bones are fused to the navicular bone, using small grafts from the tibia In the second stage, while retaining the overcorrected position the tendo achillis was lengthened and the entire foot was fixed in a plaster of paris cast It has been found that certain flat feet were due to inward rotation of the tibia and good results have been reported by correcting this by means of osteotomy

The indications for operations are limited since there are few

cases in which patients do not respond to conservative treatment. Furthermore, it is difficult to convince the parents of a small child that he should undergo an operation for flatfoot. Correction of the deformity in the child is the best means of preventing flatfoot in the adult.

In the presence of a deformity however it is necessary to correct the pes valgoplanus even if it requires surgery. Operative corrections consistent with the accepted concepts of the development of flat foot have preference. Manipulation to reestablish normal position is the method of choice. The Haglund footboard Thomas wrench

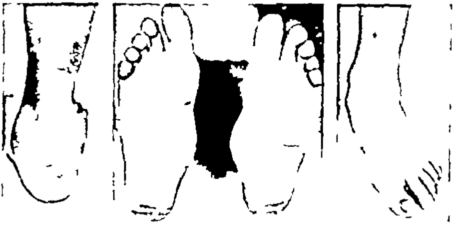


Fig. 33 Adolescent flatfoot, showing the valgus at the heel and the loss of the longitudinal arch

and the special wrench for supination may be used to obtain the corrected position which is then held by means of a cast to permit walking (see pp 381 and 395) Of the more extensive operations good results have been reported from arthrodesis of the talus and navicular bones or from fusion of the navicular and cuneiform bones

Static Pes Valgoplanus in Adolescence. *Etiology* Functional decompensation at this age is due to an imbalance between the strength of the structures and the demands made upon them This imbalance is set up by rapid growth, inadequate diet weak muscles and by overstrain from long standing or walking. Trauma is also a factor a sudden wrench sometimes bringing about an acute strain

Adolescent static pes valgoplanus occurs most frequently in those who are learning a trade In this country the most frequent causes are rapid growth and the prevention of use by such means as commercial arch supports

Symptoms The symptoms are altered gait often pain in the

region of the first cuneiform and navicular bones, aching about the ankle and up the calf of the leg and at times sharp pain in the anterior group of leg muscles The foot becomes puffy, and there is some swelling around the ankle; there is also excessive perspiration The heel is in valgus, and there is pronation at the tarsus and a dorsal displacement of the first metatarsal bone (Fig 33) The gait is therefore abnormal. The feet are externally rotated, and the weight of the body is shifted from one foot to the other The foot does not work from heel to toe or lift the body weight in the normal

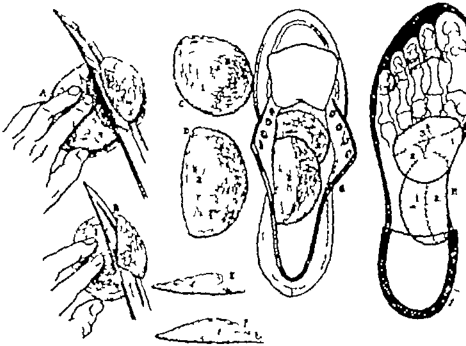


Fig 34 Felt pads A and B Method of shaping anterior pad to obtain inclined planes C Completed anterior pad, top view D Completed longitudinal pad top view E, End view of anterior pad F End view of longitudinal pad G Pads in position in the shoe. H Relation of pads to metatarsal heads

manner instead there is a falling forward of the body, and the foot is used to catch the body weight rather than to propel it. The result is a heavy shuffling, flatfooted gait.

This condition if neglected and allowed to continue, frequently results in so-called "spastic flatfoot" which will be discussed later

Conservative Treatment The acute foot strain is relieved first; later efforts are centered on increasing the strength of the foot so that it can meet the demands made upon it. In severe cases, rest in bed is prescribed when there is irritation and muscle spasm

hot packs are applied Light massage helps obtain relaxation

After the acute inflammation has subsided, or when it is impossible for the patient to stop his work even temporarily relief can be obtained by a Gibney bandage (p 375)

Arch supports help to give relief In my experience the best type is made of moderately firm felt (Fig 34) This gives a semi elastic support with the properly inclined plane and can readily be made to fit the individual foot The felt is trimmed with a sharp knife to give the proper incline to the support and is placed under the medial longitudinal arch so as to bring the posterior part of the foot into supination and the heel into varus The anterior part of the foot is brought into pronation by means of a felt pad with an inclined plane sloping from the lateral to the medial surface. This pad begins medial to the fifth metatarsal bone and slopes toward the first metatarsal It is placed immediately posterior to the heads of the metatarsal bones *

The object of treatment is not only to relieve symptoms and to correct the deformity but also to increase functional capacity The patient is instructed to have systematic rest periods that will fit the demands made by his occupation Elevation of the limbs when possible, is recommended To increase strength of the foot it is important to use all measures possible to increase the general strength of the patient General hygienic measures such as fresh air sunshine and tonics, are recommended when indicated With the foot in valgus and pronation walking increases the deformity Unless the deformity is corrected exercise will result in further strain with an increase of the disability The deformity prevents normal use of the foot in walking and therefore must be corrected

The preferred treatment is functional exercise in the form of a correct gait (p 48) This reestablishes the normal relationships of the bones to each other The first requirement is a proper shoe A shoe essentially the same as that prescribed for children is used, and the program described on page 40 is carried out

Operative Treatment The best results seem to have been obtained by the use of the periosteal graft from the tibia to the navicular bone Conservative treatment however has made the indications for operative intervention rare or exceptional

In the adolescent, it has been my experience that the flatfoot that requires surgical intervention is practically always a spasmodic flatfoot This will be considered in a separate chapter The treat

* These pads can be obtained from Michigan Avenue Shoe Repair Inc 112 East Superior Street, Chicago 11 Ill.

ment of pes valgoplanus associated with os tibiale will likewise be discussed separately

Static Pes Valgoplanus in the Adult. *Etiology* A neglected pronation deformity in adolescence will give rise to pes valgoplanus in the adult and the latter may develop at any time during the adult period Varying degrees of deformity may be present, depending on the duration and severity of the causative factors

Prolonged standing, especially on hard floors is the most common cause of pes valgoplanus in the adult The work of the waiter, policeman, clerk, salesman school teacher housewife, dentist, intern or nurse frequently requires such prolonged standing.

Pregnancy is another cause for the development of the pronated foot in women, the principal factors are increased weight and weakened structures Obstetricians have observed that patients alter their gait and posture during pregnancy in order to gain stability

After the age of forty years there is a tendency for persons to exercise less and to overeat The increased load on weakened muscles leads to a postural disturbance, and a functional decompensation results

In women who have a higher proportion of static flatfoot disorders than men, the type of shoe is an important contributing factor The shoe with a high heel and small weight bearing surface, the pointed toe, and the thin sole, is not adapted for standing and walking

Acute infections, and occasionally specific arthritis, in the foot will bring about decompensation and a resulting pes valgoplanus The presence of flatfoot in cases of chronic arthritis will be considered separately

Symptoms Patients usually complain of pain and burning in the foot. The foot gets tired and there is an aching pain in the leg particularly after long standing or walking Calluses occur some of which are painful Patients notice an increase in the length of the foot as well as in its breadth and complain of having difficulty in buying shoes Some wear a shoe as much as two or three sizes longer or wider than they did before the time their trouble started Most of them resort to stiff shanked shoes or to some form of arch support.

Pain and tenderness occur over the navicular area Some patients attempt to relieve the strain by standing on the outside of the foot. Frequently there is interference with circulation and a feeling of congestion with a sense of heaviness in the foot. Fatigue may be present not only in the foot and leg, but in the back as well. Commonly a muscular insufficiency of the back with low back pain is

associated with the static flatfoot of the adult. There is often also an increase in body weight and weakness of the abdominal muscles

The general circulation is impaired as a result of these changes the leg shows varicosities and there is swelling or puffiness above the ankle Sometimes there is a purplish discoloration of the foot. Associated with the pronation of the foot are deformities of the toes A bursitis with a hallux valgus and contracted toes with dorsal calluses may be the predominating symptoms

Examination will show swelling at the ankle, puffiness with fat pads below the malleoli varicosities contracture of the toes and

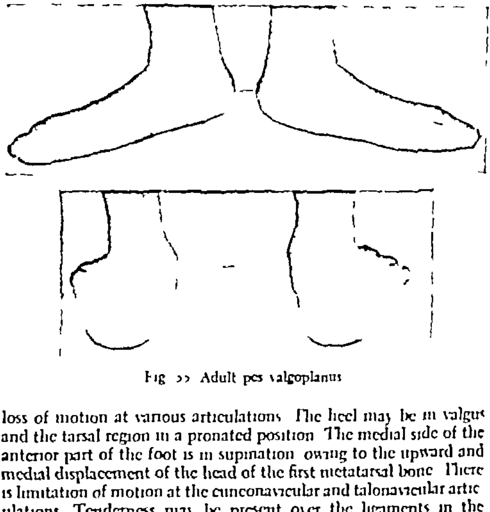


Fig 35 Adult pes valgoplanus

loss of motion at various articulations The heel may be in valgus and the tarsal region in a pronated position The medial side of the anterior part of the foot is in supination owing to the upward and medial displacement of the head of the first metatarsal bone There is limitation of motion at the cuneonavicular and talonavicular articulations Tenderness may be present over the ligaments in the region of the navicular bone The anterior part of the foot will show some spread, so-called "spreadfoot" The head of the talus and the navicular bone may be prominent and lowered (Fig 35) Roentgenograms will show the altered position of the bones to each other

with lowering of the longitudinal arch spreading of the anterior part of the foot and a valgus deformity of the great toe. When the con dition is of long standing, arthritic hypertrophic changes may be seen at the articular surfaces

Differential diagnosis consists in ruling out tuberculosis, gout, rheumatic fever gonorrhea, arthritis, tabes dorsalis, neuralgia, cal caneal spur, osteomyelitis, traumatic periostitis, bursitis, neuritis, ganglion acute bone atrophy, exostosis, and inflammation of the aponeurosis or of the plantar fat pad A roentgenogram of the foot is an aid in establishing the diagnosis as is the blood Wasser mann test, leukocyte count and a blood uric acid determination

Conservative Treatment In the presence of inflammation the patient is put at rest with the foot elevated and hot packs are applied Moist towels are put over the foot and leg, and radiant heat is directed on them To expedite recovery, this may be kept up continuously, but it is usually more practical to do it at inter vals of an hour or two at a time As the acuteness subsides, and particularly if a reflex spasm has been present, gentle massage is of value In the subacute stage the application of a Gibney band age, with the heel held in varus, is recommended (p 375) This is most satisfactory in cases of acute strain of brief duration

For the weak foot without much deformity the use of felt pads usually gives immediate relief (Fig. 34)

In the presence of a contracture when correction is painful, physi cal therapy as described on page 386 is useful. Once the foot is pliable again treatment is carried forward by reestablishment of normal anatomic relationships and functional exercises by means of corrective shoes and normal gait.

CORRECTION WITH SHOES AND PROPER GAIT A pair of shoes such as described on pages 41 and 42 is brought in by the patient. After they have been checked carefully for size, felt pads are inserted (Fig 34) and the patient is taught to walk with a normal gait (p 48) At home he practices the gait and becomes accustomed to the shoes After a week or two the shoes are returned for outside correction

The corrections consist in a Thomas heel and a comma-shaped bar (Figs 36 and 37) The Thomas heel is ½ inch longer and $\frac{1}{16}$ to $\frac{1}{8}$ inch higher on the inside and is used to bring the heel of the foot into varus and to prevent depression in the region of the head of the talus

The comma-shaped bar is used to bring the forefoot into prona tion This bar lies immediately proximal to the heads of the meta tarsal bones and relieves the strain on them It begins medial to the

fifth metatarsal bone since this bone is normally weight bearing and is lower than the middle metatarsal bones The bar is ¼ to ⅜ inch higher on the lateral side than the inner side.

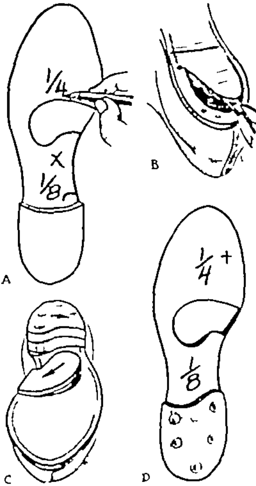


Fig. 36 Steps in correcting a shoe. A, Marking prescription on sole of shoe for guidance of shoemaker An outline of the size and location of the Hauser bar is drawn on the sole. The ¼ indicates the difference in height between the lateral and medial side of the bar The "x" signifies that the steel shank should be removed The crescent marks the forward advancement of the heel and the ⅛ the amount of elevation of the medial side of the heel *B* Removal of steel shank *C* Illustration of inclined planes directed laterally on the heel and medially on the bar *D* Completed corrections

Since the heel is raised on the inner side and the bar on the outer side there will be a twist in the region of the longitudinal arch Therefore any metal shank that prevents this twist must be removed

After the corrections have been applied the patient again prac

tices normal gait under supervision At home he practices for five or ten minutes several times a day Older people or those who have severe contractures must limit practice to as little as a minute, five or ten times a day Gradually these periods can be increased in length and frequency Interspersed rest periods are helpful

The corrective shoe almost invariably becomes more comfortable than the supportive type of shoe The amount it is worn varies with

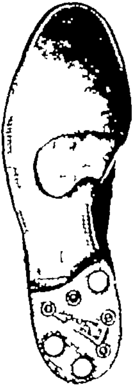


Fig. 57 Man s corrective shoe, showing the advanced heel, raised on the inner side and the comma-shaped transverse bar raised on the outer side

individual needs Most patients however desire to carry out correction until the normal is reached when this is possible. Men usually prefer to wear corrective shoes constantly Women substitute street or dress shoes when the occasion demands

Women who have worn high heels for years may have a short heel cord which causes distress on wearing a low heeled shoe It is unnecessary to lengthen the tendon by surgery The tendo achillis can be stretched by wearing the corrective shoes for short periods to be increased with tolerance

Operative Treatment. Operative treatment for adult static pes

valgoplanus consists in manipulation soft tissue operations and bone operations These methods should be resorted to, however only when conservative treatment by means of corrective shoes and physical therapy is inadequate.

The indications for operative intervention are firmly fixed contracture at the talocalcaneal articulation and ligaments in the region of the ankle Sometimes the contracture in the region of the tarsal area is so firm that it will not permit the anterior part of the foot to be forced into pronation In the anterior part of the foot the elevated position of the heads of the first and fifth metatarsal bones may be so firmly fixed that it would be impossible to replace them in their normal positions and the tendo achillis is occasionally foreshortened to such an extent that it is impossible to walk comfortably without heels on the shoes

Neurasthenia is a definite contraindication to surgery of the foot

MANIPULATIVE TREATMENT Under general anesthesia the heel is forced into varus first by manual manipulation If the force is not adequate a Thomas wrench (Fig 187) may be applied to the heel. One lever is pressed against the outer side of the calcaneus and the other lever is placed on the medial side of the tibia Force should be applied slowly and gradually so as to stretch the tissues rather than tear them This correction is repeated until the heel can easily be brought into the varus position and a normal range of motion is present

In a similar manner the medial side of the foot is grasped and tenorly and with the heel held in varus the first metatarsal bone is forced downward and brought into pronation Here again if the contracture resists manual force, leverage can be obtained by means of the mechanical wrench adapted for this purpose (see Fig 188) The first and fifth metatarsal bones are then forced downward while the heads of the other three are pressed upward

The technic for doing this consists in running the fingers on the plantar surface beneath the heads of the second third and fourth metatarsal bones The operator s thumbs are then placed dorsally one on the head of the first metatarsal bone and the other on the head of the fifth exerting force downward

In most instances there is also a contracture of the tendo achillis This tendon is stretched by dorsiflexing the foot The contracture of the tendo achillis is usually stronger than can be corrected by manual manipulation Here the Haglund footboard increases the leverage and empowers the operator with a force that will gradually stretch the shortened posterior group (see Fig 186) The manipula

tion may be repeated several times until the correction is obtained easily

The foot is then put into a plaster of paris cast from the tip of the toes up to the knee, the cast being molded to retain an over corrected position In applying the cast, care is taken not to take all the correction obtained by means of the manipulation Less correction than was actually possible by manipulation should be taken in the cast, which will guard against any danger of pressure sores, provided, of course, that the cast is molded properly

Pain usually subsides after about twenty four hours A heel may then be attached to the cast, and the patient is encouraged to walk in the cast The time the cast is worn depends on the ability of the patient to walk. As soon as he is able to walk well in it, usually in two or three weeks, the cast is removed and the corrective shoe is prescribed

Whenever possible, it is best to stretch the shortened tendo achillis rather than lengthen it, inasmuch as the lengthening is done to some extent at the expense of strength Open operation on the tendo achillis is sometimes preferred since it gives control of the amount of lengthening desired After manipulation of the foot, a contracture may remain at the interdigital and metatarsophalangeal articulations The contracted capsules and ligaments may be ex posed and, with a sharp scalpel divided at the articulation or with a periosteal elevator the attachments can be separated from the surrounding bones.

SURGICAL TREATMENT Operative procedures are primarily osteot omies Osteotomies have been performed on the calcaneus so as to bring the attachment of the tendo achillis medially downward and forward Supramalleolar osteotomies have likewise been performed Wedges have been removed in the region of the head of the talus and navicular bone

Another type of operation that may be used, particularly in cases of arthritic change is arthrodesis of the talocalcaneal articulation This eliminates pain in the joint, and the heel is brought into an improved position without danger of any recurrence. In advanced cases of pes valgoplanus in the adult with arthritic changes arthrodesis of the talonavicular calcaneocuboid and talocalcaneal artic ulations is useful

Arch Supports. Since the symptoms of static flatfoot are due to a functional decompensation one can readily understand that support and protection will give relief Arch supports have been used for years and if they are properly made, provide relief If the decom

pensation is due to acute strain or to some other factor which can be removed readily then there is no harm in a protective mechanism to carry the foot through this phase, but even here other methods, such as strapping rest heat and massage are usually preferable If the supports are worn continuously however it is inevitable for the foot to become weaker and thus subject to more decompensation When worn by the young adult the symptoms and deformity will ultimately increase. Patients who have worn supports give a history of having obtained relief at first but later their symptoms returned to a more severe degree Once worn supports are difficult to discard unless replaced by the accepted methods of treating flatfoot

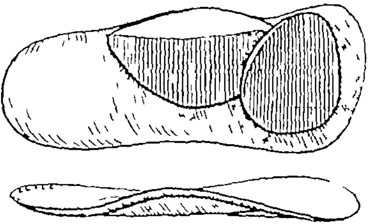


Fig. 38 Arch support showing the inclined plane directed laterally under the longitudinal arch, and the inclined plane directed medially in the region of the transverse arch

The use of arch supports should be limited to cases in which it is either not possible or not practical to reestablish the foot in normal function The much advertised commercial arch supports are condemned since it is impossible for one type of support to fit every foot. One could scarcely expect them to be a panacea for all disorders of the foot A certain percentage of wearers will obtain temporary relief of their symptoms the rest will obtain no benefit None is benefited in the sense of a cure This likewise holds true for so-called "arch supporter shoes in which a rigid support is built into the shoe

Preference should be given to the pliable type of arch support those of felt are the simplest to construct Sponge rubber can be used, although it is more difficult to shape to fit the form of the individual foot The molding of soft leather pads to form an inclined plane may give satisfactory relief It is difficult however to readjust

this type of support continuously for the changing foot, and a type of support has been devised in which inserts may be placed in a leather holder so that a gradual increase or decrease of the height may be obtained readily

Rigid arch supports may be made of metal such as duralumin or aluminum or of plastic material These appliances not only support but also protect and immobilize, the irritated articulations To assure comfort they must be fitted accurately to the foot. A mold of the foot is made in plaster of paris and a positive is made to which the arch support is fitted The part of the support that corresponds to a point of tenderness is depressed and the points that are to receive weight bearing are raised The primary requisite of any arch support is that it be made to consist of an inclined plane from the medial to the lateral side in the region of the longitudinal arch, and a transverse inclined plane directed medially posterior to the heads of the four medial metatarsal bones (Fig 38) Furthermore, care should be taken that the raise in the arch support will fit well posterior to the heads of the metatarsal bones When the first metatarsophalangeal articulation is to be fixed, it will be necessary to extend the arch support beyond the head of the first metatarsal bone The anterior part of the raise should be formed so that the heads of the first and fifth metatarsal bones lie on the same plane; the other heads of the metatarsal bones are raised

SPASMODIC PES VALGOPLANUS

Spasmodic pes valgoplanus is a rigid deformity in which the heel is held in valgus and the tarsal area in pronation as a result of contractures due to muscle spasm

Etiology The condition is caused by a strain either acute or chronic Local infection may play a role Once an articulation becomes inflamed, it acts as a point of least resistance and the inflammation has a tendency to be prolonged Since the condition is due to reflex nerve involvement nervous fatigue must be considered another causative factor The acute strain is usually traumatic in origin a sudden twist having set up irritation and reflex muscle spasm (Fig. 39) A chronic strain is the result of a functional decompensation which has become intense The rapidly growing youth who is subjected to extreme occupational strain is the most frequent sufferer The disease has become less frequent with improved working conditions and legislation regarding child labor

A decompensation results in strain not only of the muscles but also of the ligaments An irritation is set up near the articulations

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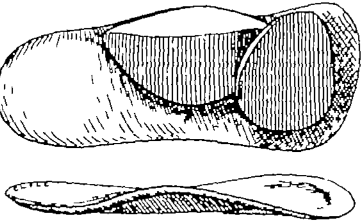


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A decompensation results in strain not only of the muscles but also of the ligaments An irritation is set up near the articulations

with a resultant reflex muscle spasm which acts as a protective mechanism The contractures of the muscles are similar to those that occur in inflamed articulations elsewhere in the body When the talocalcaneal and the talonavicular articulations become inflamed, the muscles that control these joints are stimulated to reflex spasm The more powerful group is the everters Contracture into the everted position is not entirely due to the greater power of the muscles however since leverage and gravity are also factors The tendency in a decompensated foot is toward a valgus deformity of the calcaneus and a pronation of the tarsal area The inflammation

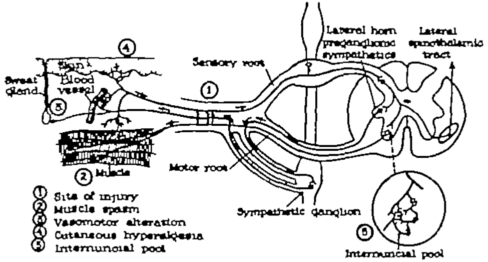


Fig 39 Diagrammatic representation of sources of stimuli producing causalgia and reflex muscle spasm

in the articulation results in a spastic contracture of the muscles, so that there is fixation in the deformed position

Symptoms. The symptoms of spasmodic pes valgoplanus are pain fixation of the foot, a pes valgoplanus deformity a flatfooted gait and frequently a limp The condition is often bilateral, and is usually more severe in one foot than in the other The pain occurs in the region of the inflamed articulation Tenderness can be elicited over the lateral talocalcaneal area, and occasionally over the talonavicular and the cuneonavicular areas Any attempt to move the heel into a varus position is painful The peroneal muscles are tense, and the tendons stand out like fiddlestrings The tibialis anterior tendon and sometimes the extensors of the toes are frequently involved in the spasm Motion at the talocalcaneal articulation and in the tarsal area is lost or limited. Attempts at passive motion cause pain

Pain is frequently referred to the muscles of the leg, and cramps are not uncommon The spasm is worse after standing and walking, but continues even while the foot is at rest. The gait is typically flatfooted, with the foot externally rotated, and consists in a shuffling rather than a rolling motion of the foot. The foot shows loss of the longitudinal arch Nervous fatigue is frequently a common secondary symptom

Roentgenograms in advanced cases show arthritic changes at the talocalcaneal and tarsal articulations There may be an alteration in the form of the bones with loss of articular surfaces Exostoses are present at the margins

Treatment *Prophylactic Treatment* Prophylactic treatment consists first, in the avoidance of prolonged foot strain in adolescents Once a strain has expressed itself in the form of painful feet, the condition should not be neglected The early stages should be remedied by protection against strain, and this is best done by means of periodic rest. When adequate rest cannot be obtained a protective type of treatment will be necessary Rigid arch supports should be avoided even though they give temporary relief inasmuch as the structures will be weakened and the foot subject to an even more severe decompensation

Provided adequate rest is assured correction can be attained by means of the corrective shoe described for the treatment of static flatfoot. The occurrence of spasmodic flatfoot in the adult can therefore be prevented if the early symptoms are heeded and if corrective treatment is instituted

Conservative Treatment Conservative treatment is indicated in the presence of muscle spasm without contracture; it consists in rest in bed and the application of hot packs A posterior splint may be applied Immobilization may also be attained by means of a compression bandage, which consists of three or four layers of sheet wadding snugly wrapped with a 3-inch gauze bandage from the toes to the knee As the acute phase subsides light massage may be instituted and active motion gradually encouraged. Paraffin packs are sometimes useful, and when practical warm sand or treatment by means of a flow of warm air will be beneficial

Since this is a reflex muscle spasm due to inflammation at a joint, any manipulation that will further irritate the joint is contraindicated An anesthetic may be used to block this reflex spasm and allow the foot to be brought into a corrected position This may be accomplished either by local or general anesthesia When using local anesthesia the skin just anterior to the tip of the lateral mal

leolus is cleansed with zephiran chloride, 1 1000 solution and 5 cc. of 2 per cent procaine are injected through a hypodermic needle into the sinus tarsi The anesthetic relaxes the foot so that the valgus position of the heel and the pronation of the anterior part of the foot can be obtained This position is then held by means of a simple adhesive strapping and concurrently normal gait is started by means of the corrective shoes The procedure is repeated as indicated, weekly intervals have been found to be satisfactory in most cases More correction is taken at each subsequent visit. With correction of the foot the joint irritation subsides and the muscle spasm relaxes

There are some resistant cases that require general anesthesia in order to obtain muscle relaxation and allow correction of the position of the foot. In most of these cases general anesthesia gives sufficient relaxation so that correction of the foot can be readily obtained. The corrected position is held with a plaster of paris cast and walking is started in the cast. In the more chronic cases it is necessary to stretch the contracted ligaments and muscles by means of manipulative force. This can be done by the use of a Thomas wrench, the Haglund manipulative footboard and the special lever for the anterior part of the foot, after which the corrected position can be fixed with a cast. (See description of technic, Chapter 29)

Operative Treatment Operative treatment directed against the nerve has been advocated and consists in the application of pressure against the peroneal nerve. This can be done externally by means of elastic bands More direct pressure is achieved after exposure of the nerve under local anesthesia and a compression which then causes temporary paralysis A similar procedure is to freeze the nerve with ethyl chloride after exposure A simpler method is to obtain temporary relaxation by means of the injection of 2 per cent procaine into the muscle or in the area of the nerve Exposure and tearing of the nerve are, of course, contraindicated inasmuch as they leave a paralysis

There are two objections to this type of operation it is difficult to know how much permanent injury will result, and it is impossible to correct the contractures at the joint by treatment of the nerve alone. It is problematical also how advisable it is to eliminate the function of the peroneal group even temporarily

In severe cases with spasm manipulation under anesthesia followed by the application of a cast even if this has to be repeated several times still holds the preference In advanced cases with arthritic changes fusion may be considered The treatment in such a case would consist in as much correction as can be obtained by

means of manipulation, followed by fusion of the talocalcaneal and talonavicular articulations in order to eliminate pain and retain the best position

Postoperative Treatment The postoperative treatment consists in permitting weight bearing in the cast once the correction has been attained. A heel is applied to the cast to facilitate walking In the early stages a walking caliper (see Fig 181) attached to the cast may be used. As soon as walking in the corrected position in the cast is accomplished easily the cast may be removed and corrective shoes are prescribed A cast may be necessary for three weeks to three months The amount of exercise permitted in the way of corrected gait is first definitely limited and then increased gradually If the amount of use required for practical reasons is higher than that indicated by the strength of the foot the foot can be strapped with a Gibney bandage with the heel held in varus and the anterior part of the foot in pronation (Fig 177)

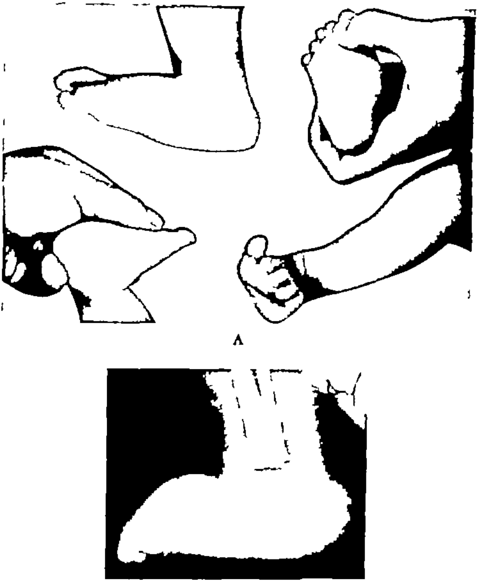
CONGENITAL PES VALGOPLANUS

Incidence. True congenital flatfoot is of infrequent occurrence contrary to the common conception that it is often hereditary Some believe that the percentage of congenital flatfoot is high—5 or even 10 per cent. It is not uncommon however for a patient to complain of flatfoot which he says he inherited or to say that it "runs in the family" Children frequently imitate the gait of their parents and of older children in the same family

The newborn have a definite arch but there is some variation in the height of this arch at the time of birth. This variation can proceed to the point where we could speak of the foot as being in a pronated and valgus position In the course of natural development this position changes to the normal without treatment When the child first puts his weight on the foot, the structures are not adequate to sustain the normal position By practice and exercise the child gradually develops enough strength in his feet to support his body and in so doing establishes the normal relationship of the bones to each other If the foot is observed at this developmental period one sees a pes valgoplanus Inasmuch as this is a developmental phase which occurs in the normal it should not be classed as a congenital flatfoot but as a static flatfoot.

Etiology Congenital pes valgoplanus is a distinct clinical entity of infrequent occurrence At the time of birth the position of the feet is peculiar The legs cross below the knees and one foot rests anterior to the other both feet being in dorsiflexion and extreme

valgus The striking part of the deformity is the convex form of the sole (Fig 40)



A

B

Fig 40 Congenital flatfoot in an infant *A*, Valgus position of the heel, pronation of the foot and dorsiflexion The foot has already been partially corrected *B* Roentgenogram of the same foot

The disorder has been said to correspond to an early fetal position of the foot and therefore could be an arrest in the developmental process (Fig 41) The condition may on the other hand be a structural anomaly since there sometimes is a concomitant occurrence

of anomalies in other parts of the body. The posture of the feet at the time of birth forces them into definite pes valgoplanus, and this position in itself might explain the presence of the deformity. The opinion has also been expressed that the condition may be due to amniotic interference.

The significance of this etiologic discussion is that, in case of a postural disturbance, the correction would be comparatively simpler than if it were due to an anomaly. However, if a congenital anomaly

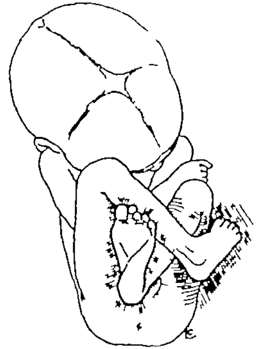


Fig. 41. Sketch of fetus showing left pes valgoplanus and right equinovarus caused by fetal position. (After Cramer.)

and defects are present, then even with correction of the deformity the foot will still not be normal.

Clinical experience suggests the existence of both types, inasmuch as certain congenital flatfeet can easily be restored to normal, whereas others retain some part of the deformity in spite of all efforts toward correction.

Symptoms. The deformity is apparent at the time of birth, it being as evident as the equinovarus deformity or so-called clubfoot. Both feet may be involved, but the deformity may be more extreme in one foot than in the other. In a severe deformity dorsiflexion may be so extreme that the dorsal surfaces of the toes are in contact with the anterior part of the leg. The calcaneus is displaced laterally

and the valgus is so extreme that there is *subluxation at the talo-calcaneal articulation* Frequently in spite of the extreme dorsiflexion of the foot, the calcaneus remains underdeveloped and the posterior group of muscles with the tendo achillis are short, so that the calcaneus is drawn upward The pronation is so extreme that there is a protrusion of the tarsal area *of the foot resulting in the* sole of the foot having a convex form The toes are contracted forming a claw

Treatment. The early institution of treatment is important. As soon as the first day after birth corrective measures may be instituted. The treatment consists *in bringing the foot into the opposite direc*tion and holding the overcorrected position This is best done by means of cohesive bandage. The cohesive bandage* is one which sticks to itself but does not adhere to the skin. The foot is brought down into plantarflexion stretching the dorsiflexors. The heel is *held in varus, and the great toe and the head of the first metatarsal* bone are brought plantarward In bringing the foot plantarward the dorsiflexion is corrected. By bringing the heel into varus and the first toe plantarward the longitudinal arch is reestablished. Since the first metatarsal bone is lower than the second and third a transverse arch is formed. Thus the restoration *of the position of the foot* is brought about. The corrected position is held by means of the cohesive bandage. In order to obtain a support that will counteract the pull of the muscles, the cohesive bandage is reinforced with waterproof adhesive tape.

The technic for applying *the cohesive bandage is first to com*pletely encase the leg and foot with the bandage, overlapping each turn by half as it is wound. Then start the cohesive on the lateral *side of the heel and, drawing the heel into varus, run the bandage* beneath the sole of the heel and up the medial side of the leg, where it becomes adherent *to the original bandage This step may be re*peated three or four times as necessary to hold the varus position. Next, start a bandage on the dorsum of the great toe, and pulling the great toe plantarward draw the bandage around the bottom of the anterior part of the foot and fasten it to the encasement bandage anterior *to and above the ankle. This step is* also repeated three or four times obtaining as much correction each time as possible. To correct the dorsiflexion the foot is brought plantarward and the encasement is reinforced anterior to the ankle with several layers of cohesive bandage Counteraction of the pull of the muscles and

* *Manufactured by Johnson and Johnson, Chicago*

firmer fixation are then obtained by reinforcement of the cohesive bandage with waterproof adhesive tape. The adhesive tape is applied with the same technic as was used for the cohesive bandage

The bandages are renewed at intervals of one to three weeks, each time taking more correction than was previously obtained In the early part of the treatment the correction goes rapidly; therefore the bandages should be changed more frequently Often over correction is obtained before the child begins to walk, but it is well to hold the correction obtained until the child learns to walk and muscle balance has been established After the child walks correc



Fig 42. Roentgenogram of neglected congenital flatfoot, showing "rocker bottom" deformity

tion is retained by means of corrections on the shoes This correction is the same as for flatfoot in childhood as described under Treatment for Pes Valgoplanus (p 55)

The severity of the deformity varies a great deal In some the contracture is so mild that the foot corrects itself spontaneously after the child is born in others the deformity may be severe with definite contractures which have to be stretched gradually

Occasionally a neglected congenital flatfoot is seen in which case there may be impairment of function and a lack of development in the foot and leg (Fig 42) In these instances manipulation is carried out by means of the Haglund footboard and the wooden wedge, and the correction obtained is held by means of a plaster of paris cast The child walks in the cast for a period of six to eight

Treatment When the condition is recognized in early childhood, an operation has been suggested in which the bridge is exposed divided and the interspace filled with a strip of muscle to prevent reunion If the condition has been of long standing talonavicular arthrodesis and possibly also talocalcaneal arthrodesis will relieve the symptoms.

I have seen two cases both of which were relieved by the corrective shoe and the treatment used for flatfoot in the adolescent.

Fusion of Calcaneus and Talus Bones. Occasionally a bridge of bone unites the sustentaculum tali of the calcaneus to the talus It has been found to exist in the absence of symptoms Recently the presence of this bridge has been cited as the cause of spasmodic flatfoot. If it is recognized early conservative treatment suffices In the later stage with severe deformity subtalar arthrodesis may be necessary

Fusion of Calcaneus and Cuboid Bones. A case has been described in which the calcaneus and cuboid bones were fused. The longitudinal arch was depressed the navicular bone was prominent, and motion was normal There were no symptoms

Although of infrequent occurrence, recognition of these conditions is important, since they must be differentiated from the static type of flatfoot, particularly with regard to prognosis and treatment.

Pes Valgoplanus Associated with Congenital Absence of the Fibula. In this type of congenital flatfoot the heel lies in extreme valgus In unilateral cases definite shortening of the limb develops, as much as 3 or 4 inches and constitutes the principal deformity An elevated shoe should be worn but the valgus at the heel should be corrected in order to obtain better weight bearing To get the heel into normal position it may be necessary to carry out a manipulation followed by a plaster of paris cast

Pes Valgoplanus Associated with Os Tibiale (Flatfoot with Accessory Scaphoid) A third form of pes valgoplanus that can be considered under the congenital type is the flatfoot with accessory scaphoid which is seen in children In the presence of an os tibiale, an inflammatory reaction occurs as the result of continued trauma in the region of the accessory bone. The bone is enclosed in the posterior tibial tendon the tibialis posterior is displaced and there is a change in its pull. During the acute phase the condition is easily recognized by tender firm swelling over the area of the accessory bone A roentgenogram will reveal the accessory bone

Treatment The acute phase is relieved by rest and heat The foot is elevated on pillows and a moist pack is applied with an infra

red lamp to maintain continuous heat Relief of the acute symptoms is usually obtained in about a week, and treatment may proceed with corrective shoes and reestablishment of a normal gait as described in the treatment for static flatfoot

Satisfactory results can also be obtained by surgical procedures which consist in removal of the accessory bone after the inflammation has subsided entirely The os tibiale should be removed, in addition the tibialis posterior should be transplanted to the under surface of the talus During the operation the foot is held in a supinated position which allows for a shortening of the tibialis



Fig 45 Pes valgoplanus due to anterior poliomyelitis

tendon and for reestablishment of the normal function of this muscle. The operation is successful but if the conservative treatment is carried out correctly it is not necessary to resort to it

PARALYTIC PES VALGOPLANUS

Paralytic flatfoot is an acute deformity usually of a severe degree and with extreme pronation in the tarsal area which expresses itself in a complete loss of the longitudinal arch (Fig 45)

Etiology The paralysis in most cases is due to anterior poliomyelitis The muscles involved will vary from one or two of the inverters, such as the tibialis anterior and tibialis posterior *to complete* paralysis of the foot In some instances the paralysis may in

volve the everters as well as the inverters—in which case the weight bearing will decide the type of deformity, and the static deformity in the foot will be a valgus at the heel and a pronation in the tarsal area

Thus the determining factor in the type of deformity is not entirely dependent on which muscles are involved in the paralysis, but is influenced by the weight bearing.

Symptoms. An important symptom is instability, due primarily to the excessive medial and lateral motion at the talocalcaneal joint. In severe cases there is also lateral motion at the ankle joint which contributes to the instability The deformity is apparent, and the heads of the talus and navicular bones project downward and medially frequently so far as practically to rest on the floor

The instability results in an uncertain gait and fatigue. Limp is present, mostly due to the primary paralysis In a neglected paralytic flatfoot contractures may develop, since one or more of the muscles may be active while the opponents are lost. The altered weight-bearing surfaces result in the formation of plantar calluses which may become painful

It might be well to emphasize that the important symptom is the functional loss the altered appearance is a relatively minor concern. The functional loss is to a great extent, due to the instability whereas the loss of power is due to the paralysis

Complications. In most instances the paralysis that causes a valgoplanus is associated with paralysis of the dorsiflexors which means that foot drop is present. In more complete paralysis the foot is practically flail and is termed a "dangle foot.

Treatment. *Prophylactic Treatment* In the treatment of paralytic flatfoot the important consideration is to reestablish function which means obtaining stability of the foot. Prophylaxis includes the orthopedic care of infantile paralysis. After the acute phase has subsided, the foot should be held in the midposition. When recovery has reached the point where it can be established that there is a weakness in the tibialis anterior or tibialis posterior the foot should be held with the heel in varus and the tarsus in supination while waiting for further recovery Massage and exercises are taught and supervised during this period. A plaster of paris cast is then applied with the heel in varus, the tarsus in supination and the forepart of the foot in pronation, weight bearing is encouraged. At first standing and a few steps are permitted gradually this is increased The cast is then removed and the corrective shoe is worn the amount of

exercise is again limited and gradually increased. In this way mild cases can be reestablished to practically normal function

In severe cases a similar type of prophylaxis is executed in spite of all treatment however the paralysis will lead to instability Prevention of contracture is important and is accomplished by the use of adequate braces until a satisfactory age is reached to carry out the operative treatment.

Operative Treatment. Operative treatment is usually indicated for paralytic flatfoot and consists in stabilization by means of arthrodesis The talocalcaneal articulation is arthrodesed as well as the talonavicular and calcaneocuboid joints The arthrodesis can be carried out readily through a single incision If a deformity has occurred, it is a sound principle to correct the deformity first and then carry out the fusion operation

In the presence of a mild type of deformity, in order that the preliminary corrective operation can be eliminated, it is possible to remove a wedge of bone in the region where the arthrodesis is to be performed or the head of the talus can be removed, denuded and transformed to allow full correction of the deformity when it is replaced. With the foot in midposition stability is attained

To obtain a correction of the deformity as a preliminary to fusion it may be necessary to carry out a manipulation under anesthesia with fasciotomies and tenotomies The foot is then brought into the overcorrected position the heel in varus and anterior part of the foot in pronation A plaster of paris cast is applied and weight bearing is permitted on the second or third day after manipulation The cast is worn ten days to three weeks, and then the fusion operation is carried out.

In case of an imbalance between the paralyzed muscle and its opponent, it is frequently advisable to carry out a tendon transplant For instance, the peroneus longus may be transplanted to the medial side of the foot to change it from an everter into an inverter Tendon transplant must be preceded by full correction of the deformity Fusion must be carried out at the same time Fusion may precede the tendon transplant or both procedures may be done at the same time

Prognosis. The prognosis in the early cases depends upon the amount of recovery that occurs from the anterior poliomyelitis Once paralytic flatfoot develops it will persist The fusion operation with the foot in the corrected position will give a stable foot that permits good function The amount of function depends on the

remaining power in the extremity involved and the absence of other deformities at the foot and knee.

PES VALGOPLANUS DUE TO SUPINATION OF THE ANTERIOR PART OF THE FOOT

The anterior part of the foot may be supinated, and this deformity may be either congenital or acquired The acquired type frequently

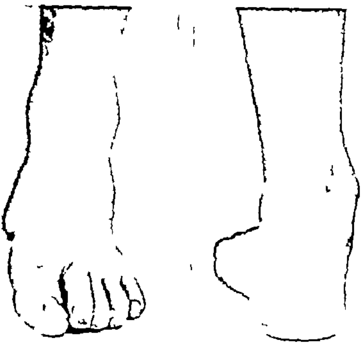


Fig. 46 Supination of the anterior part of the foot, causing pes valgoplanus Anterior view shows the supination, and posterior view shows the valgus, left greater than the right

follows fixation of the foot for fracture in the lower extremity Supination may likewise follow treatment of pes valgoplanus. To relieve strain the first metatarsal bone is elevated Holding the supination ultimately results in a contracture deformity (Fig. 46)

Symptoms. When the anterior part of the foot is placed firmly on the floor if a supination deformity is present the heel is forced into valgus. There is firm contracture with loss of pronation of the anterior part of the foot. The result is pes valgoplanus The symptoms and findings are the same as described under static flatfoot, where the anterior part of the foot is pronated Arthritic changes are not uncommon at the first metatarsophalangeal articulation

Treatment Prevention is emphasized. In treatment for fractures or other conditions where fixation is used the foot should be held in the position of choice Supination of the anterior part of the foot should be avoided as strictly as valgus position of the heel

When deformity is present, the contracture in most cases will respond to correction with the corrective shoe, used in the manner described for static flatfoot. The inclined plane of the comma shaped transverse bar is important at first the outer side of the bar is raised 1/16 inch and gradually increased until 1/4 or 3/8 inch has been reached The correction is increased as rapidly as is consistent with the patient s comfort. The heel is held in varus, the raise on the inner side may remain at 1/16 inch throughout the course of treatment.

Heat and massage are valuable adjuncts in freeing the foot so that the pronated position of the anterior part may be regained Adhesive strapping, in which the heel is held in slight varus and the medial side of the anterior part of the foot is brought down into pronation is effective.

Manipulation under anesthesia with the special wrench is limited to cases in which the contractures resist repeated adhesive strappings The foot is brought into midposition and retained in the cast Walking is permitted in the cast as soon as the pain has subsided Usually this is possible within twenty four to forty-eight hours The cast is worn three to twelve weeks It may be changed, and without anesthesia the position of the foot can be improved before the new cast is applied After removal of the cast an Unna paste boot is worn for a period of about ten days The corrected position is retained for at least a year with the corrective shoe in which the inclined plane of the comma-shaped bar is constantly repaired

METATARSUS LATUS

(*Broad Foot Spread Foot*)

Metatarsus latus is spreading of the anterior part of the foot and is due to the separation of the heads of the metatarsal bones from each other (Fig. 47) The chief deformity is a varus of the first metatarsal bone In a similar manner the fifth metatarsal bone is spread away from the fourth The ligaments and short muscles that control these bones give way while the adductors of the first and fifth toes tend to contract bringing about a hallux valgus and a digiti quinti varus (Fig 48) The heads of both the first and fifth

metatarsal bones are displaced dorsally The heads of the tarsal bones are, therefore, all on the same plane, and the for



Fig 47 Metatarsus latus Note the spread of the first and fifth metat bones

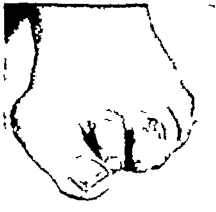


Fig 48 Metatarsus latus, showing associated hallux valgus and digiti quinti varus

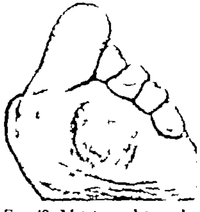


Fig 49 Metatarsus latus, plar aspect Note the calluses at the p sure points

of the foot is flat Weight bearing is decreased on the heads of t first and fifth, but increased on the heads of the middle metatars

bones There are frequently signs of pressure over the plantar surfaces below the heads of these bones (Fig 49) The increased use over a long period of time will result in hypertrophy of the second metatarsal bone

Etiology As was seen in the mechanical development of pes valgoplanus the spread of the anterior part of the foot is due to a functional decompensation This means that there is inadequate strength in the foot to meet normal functional demands The decrease in strength may be due to narrow shoes which have interfered with the development of the foot High heels with small weight bearing surfaces will throw an excessive load upon the anterior part of the foot and cause strain

Symptoms. The anterior part of the foot is wider than normal, making it difficult for the patient to purchase a properly fitting shoe, inasmuch as any shoe which fits the wide, front part of the foot will be too loose at the heel Furthermore, the spread of the first metatarsal bone gives rise to the condition described under hallux valgus Spread of the fifth metatarsal bone gives rise to a similar condition namely, digiti quinti varus with a projection of the head of the fifth metatarsal bone and a bursitis in this region The abnormal demand upon the heads of the middle metatarsal bones gives rise to pain due to pressure. Painful calluses form on the plantar surfaces and there is a tendency toward contractures of the toes The roentgenogram may show hypertrophy of the second metatarsal bone.

Treatment *Conservative Correction* The treatment for this spread of the anterior part of the foot must be directed first against the causes of the functional decompensation This consists in the use of the corrective shoe, with the heel of the shoe tilted to bring the heel into varus, the comma-shaped transverse bar throwing the anterior part of the foot into pronation At this point it should be emphasized that the transverse bar does not extend beneath the fifth metatarsal bone This permits the head of the fifth metatarsal bone to fall back into its normal plantar position on weight bearing.

Manipulative Treatment. In addition to conservative correction by means of the corrective shoe, metatarsus latus, particularly if contractures are present is benefited by heat massage and manual manipulation The foot is elevated on a pillow moist dressings are applied, and a baker or infra-red lamp heats the moist packs continuously for thirty minutes The foot is massaged to relax the muscles and improve the circulation With the thumb pressing upward against the plantar surfaces of the middle three metatarsal

bones the fingers gently force the heads of the first and fifth metatarsal bones toward each other and downward. These movements are repeated about twenty times At first this type of treatment is carried out daily and then once or twice a week, until the contracted structures relax and the corrective shoe can exert its effect without causing pain When this method of treatment is ineffective, manipulation under anesthesia may be considered

Operative Treatment In case of metatarsus varus and its associated hallux valgus in order to obtain a cosmetic result as well as symptomatic relief it is sometimes necessary to carry out an operation to correct the hallux valgus The operative procedures described for hallux valgus improve the metatarsus varus and are therefore also applicable in the treatment of metatarsus latus Likewise, the operation directed against digiti quinti varus decreases the lateral spread of the forepart of the foot.

Another operation for metatarsus latus is to expose the medial side of the head of the first metatarsal bone and drill a hole through it (Hohmann) A similar incision is made over the lateral side of the foot to expose the head of the fifth metatarsal bone. A strip of fascia lata is then obtained and passed through the opening in the head of the first metatarsal and made fast by suturing it to itself Next, a long, blunt forceps is passed medially through the lateral incision beneath the skin on the plantar surface of the foot and the strip of fascia is caught in the forceps and pulled through It is drawn taut then fastened around the fifth metatarsal bone, and sutured to itself in the region of the capsule of the metatarsophalangeal articulation The heads of the first and fifth metatarsal bones are thus drawn downward and toward the midline, correcting the metatarsus latus

After this operation the foot is fixed in plaster of paris Weight bearing is begun as soon as the wound has healed The patient walks in the cast for ten days to three weeks The cast may be changed at the end of seven to ten days in order to remove the sutures When the cast is removed an Unna paste boot is applied and is worn for about two weeks Heat and massage are prescribed and the corrective shoe is worn

The number of cases requiring operative correction is gradually decreasing In most instances symptomatic relief and good functional results are obtained by the conservative measures described Operative procedures are gradually becoming limited to those cases in which a cosmetic result is required

REFERENCES

Boyd, H B Congenital Talonavicular Synostosis J Bone & Joint Surg., 26 682, 1944

Cotton, F J, and Morrison, G M Rigid Flat Foot—Remodelling New Eng. J Med., 210 792, 1934

Dreyley R. L. Foot Imbalance J.A.M.A., 103 1510 1934

Dunn H L. Status of Human Arch when Subjected to Body Weight. Mil Surgeon, 52 567 1923

Hauser E. D W Muscle Imbalance of the Foot. S Clin North America, 19 101 1939

Hohmann, G Fuss und Bein ihre Erkrankungen und deren Behandlung. 2d ed Muenchen Bergmann, 1934

Hoke, M An Operation for the Correction of Extremely Relaxed Flat Feet J Bone & Joint Surg., 13 773 1931

Kaplan, M., and Kaplan, T Flat Foot. A Consideration of the Anatomy and Physiology of the Normal Foot, the Pathology and Mechanism of Flat Foot with the Resulting Roentgen Manifestations Radiology 25 485 1935

Mayer Leo The Treatment of Paralytic Flat Feet J Bone & Joint Surg., 4 39 1922

Miller Oscar L. A Plastic Flat Foot Operation J Bone & Joint Surg., 9 84 1927

Nicholson J T The Surgical Treatment of Flat Foot. S Clin North America, 16 569 1936

Whitman, R A Treatise on Orthopedic Surgery 9th ed Philadelphia, Lea & Febiger 1930

6

ORTHOPEDIC CONDITIONS OF THE TOES

HALLUX VALGUS

Hallux valgus is a deviation of the great toe in an outward direction, at times this toe may overlap the second toe There is a disturbance in the alignment between the first metatarsal bone and the phalanges of the great toe. The first metatarsal bone deviates medially and the result is an angulation at the metatarsophalangeal articulation

The condition is associated with other disturbances of the foot the anterior part of the foot is spread, the tarsal area is in pronation and the heel is in valgus In other words hallux valgus is associated with metatarsus latus which in turn is related to pes valgoplanus (Fig 50)

Etiology Like pes valgoplanus, metatarsus latus and hallux valgus are caused by a functional decompensation This functional decompensation of the anterior part of the foot is dependent upon the occurrence of the pes valgoplanus deformity Furthermore, this decompensation is increased as the result of high-heeled shoes, since abnormal weight bearing is placed on the anterior part of the foot Not only a high heel but any heel that has a small weight-bearing surface will have this effect Narrow pointed shoes naturally have a further tendency to cause the deformity Thus inability to use the toe normally as a result of interference from a shoe will in every case be a factor in bringing about a functional decompensation

Another cause of difficulty is an abnormal gait which consists in rolling off the side of the great toe with the foot externally rotated, changing the normal use of the great toe in such a manner as to further a deformity in the hallux valgus direction

The valgus position of the heel gives rise to a medial and plantar displacement of the navicular bone In the presence of this pronation the medial section of the anterior part of the foot is in relative

supination Under these circumstances counter pressure from the floor will tend to displace dorsally the head of the first metatarsal bone. In so doing it forces the head of the first metatarsal bone away from the second at the same time it rotates the head of the first metatarsal bone so that the plantar surface projects medially The result of such forces is to stretch the ligaments and muscles that hold the heads of the metatarsal bones together As the head



Fig 50 Hallux valgus showing the lateral displacement of the great toe and the external rotation Note the prominence over the head of the first metatarsal bone

is displaced medially the first phalanx subluxates from its articular surface and forms the valgus deformity

In addition to these static causative factors the muscles also play a role in bringing about the deformity The extensor hallucis longus gradually alters its direction of pull so that it finally acts as an adductor of the toe The abductor hallucis is also displaced until it comes to lie on the plantar surface and acts as a flexor The entire abduction power is thus lost The unopposed adductor contracts and increases the valgus deformity of the toe In severe cases the flexors act as adductors The capsule on the lateral side of the articulation is contracted while on the medial side it becomes distended and thin Thus once the foot is thrown out of balance with a valgus at the

heel there is a tendency toward the hallux valgus condition In the presence of an altered gait which consists in an externally rotated position of the foot the weight is rolled off the inner side of the great toe This type of walking abets the formation of further hallux valgus deformity

Symptoms. The chief symptom from the patient s point of view is the inflammation of the bursa at the head of the first metatarsal bone (Fig 51) This is the result of chronic irritation The head of the metatarsal bone projects medially and causes a friction rub. As a result of the rotation the medial plantar margin projects under



Fig 51 Inflammation in the region of the bursa in hallux valgus.

the skin and this is frequently mistaken for an exostosis. If irritation has been present for a long time, a true exostosis occurs The inflamed bursa may become distended with fluid and cause intense pain As a result of chronic inflammation it becomes thickened and indurated

Since the head of the first metatarsal bone is displaced dorsally it no longer assumes its normal amount of weight bearing, the weight being transferred to the heads of the second and third and occasionally the fourth, metatarsal bones The abnormal weight bearing at these points results in the formation of calluses on the plantar surface These may become tender and painful

The medial displacement of the head of the first metatarsal bone naturally increases the width of the foot so that there is difficulty in obtaining a properly fitting shoe Frequently associated with

this condition are contracted toes and a spread of the fifth meta tarsal bone away from the fourth As a result of walking with the foot in external rotation a friction rub occurs over the medial side of the great toe, and calluses form in this area The gait is awkward and causes fatigue. The deformity of the great toe may show a slight valgus deviation, or may be so extreme that the toe is practically at a right angle and overlaps the second toe. The skin over the bursa becomes thickened and forms a callus

Sometimes the bursa becomes infected and a pyogenic bursitis may occur; or a fistula may develop which will drain for months The infection may penetrate to involve the bone.

Treatment. *Prophylactic Treatment* Prophylaxis for hallux valgus consists in prescribing a normal shoe, training in the normal gait and preventing the occurrence of pes valgoplanus Since pes valgoplanus is a factor predisposing to hallux valgus, its prevention, or its correction once it has occurred is a prophylactic treatment for hallux valgus

As long as the foot is pliable there is ready response to the treat ment described under Pes Valgoplanus Briefly, it will consist in bringing the heel into varus and the anterior part of the foot into pronation and then teaching the patient to walk with the normal heel-and toe rolling gait, using the great toe to grasp the ground in order to obtain a propulsive force. To attain such a result it is necessary to have a shoe with a straight inner last and a strong but pliable sole; to this the corrective heel and inclined transverse bar are applied. The use of this correction will prevent the development of and have a curative effect on, all the milder forms of hallux valgus The method is simple and practical and can be applied to children and men without difficulty With women the problem is compli cated by the fact that style decrees for the present at any rate, that high heels be worn at least part of the time Women patients should use the corrective shoe wherever practical, that is around the house, on the golf course, and to take walks. The dress shoe should be modified to combine satisfactory appearance with as nearly normal function as possible. A shoe with a heel of medium height and a fairly broad surface and a metal shank will serve for street wear This shoe may be pleasing in appearance and at the same time can allow a gait near enough to normal to cause no deformity For danc ing and other such social functions high heeled shoes may be worn without lasting detrimental results In any case, the corrective shoe will counteract the tendency to deformity

An acute bursitis requires immediate alleviation This is obtained

by rest in bed and by the application of hot packs to the foot. The foot is elevated on a pillow and covered with a moist towel on which an infra red lamp is directed, or it may be covered with a baker After the inflammation has subsided, the foot is protected against further irritation until correction of the underlying condition is obtained This protection may require stretching of the shoe over the region of the head of the first metatarsal bone, or it may be necessary to cut the shoe The irritation of the bursa can be alleviated by shifting the weight temporarily to the outside of the foot. This can be done by placing a felt pad with an inclined plane beneath the longitudinal arch. If a painful callus is present, paring the thickened skin in this area will give relief Friction of the skin and irritation of



Fig. 52 Bunion pad in place.

the bursa are prevented by applying a half-moon shaped felt pad dorsal and posterior to the projecting head of the metatarsal bone (Fig 52)

When for some reason correction of the deformity is not desirable, palliative treatment consists in having a shoe built to allow adequate space for the deformity In moderately severe cases stretching of an ordinary shoe may be sufficient to give adequate space for the enlargement In some instances a form fitting covering of rubber acts to prevent friction and thus alleviates the acute symptoms In those cases in which conservative correction of the deformity by means of the corrective shoe does not give a satisfactory result surgery is indicated

Surgical Treatment (Conservative) For every case of hallux valgus in childhood or adolescence, and even in the young adult,

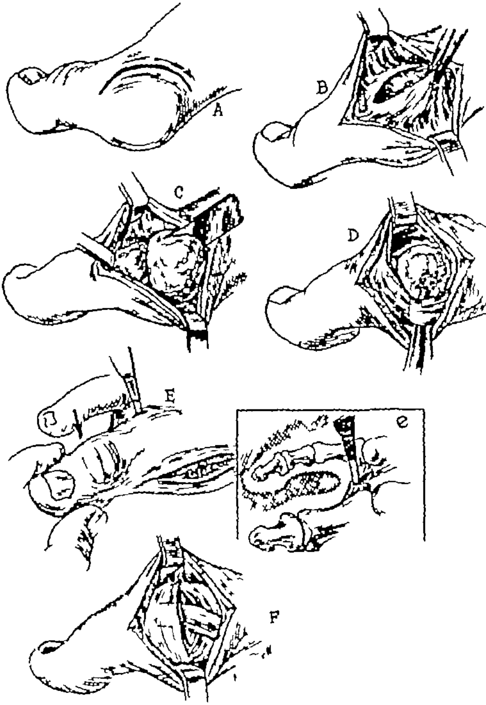


Fig. 53 Author's operation for correction of hallux valgus. A, Incision B, Excision of bursa. C, Removal of exostoses from the metatarsal head and the proximal phalanx. D Identification of the abductor hallucis, dotted line indicating the point of division at its insertion E, and e, Subcutaneous division of the adductor hallucis with tenotome F Subperiosteal transplantation of the abductor hallucis

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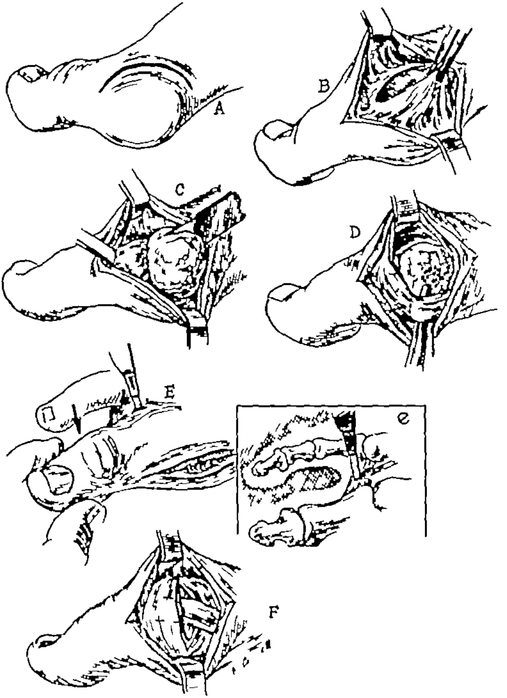


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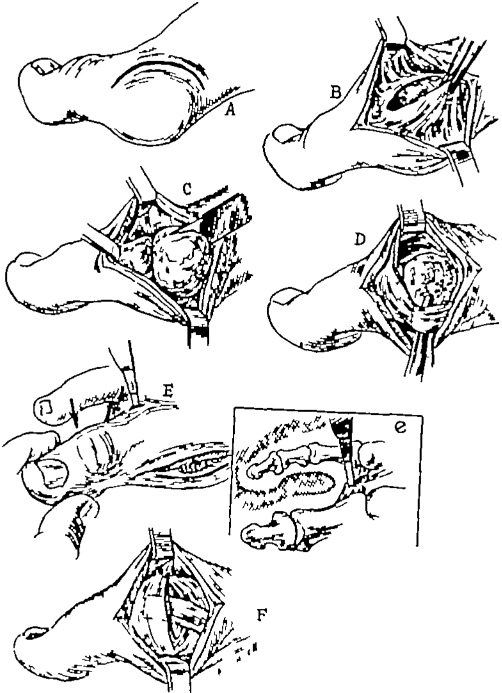


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operative treatment is limited to conservative measures This type of operation is indicated whenever there is not a complete pes valgoplanus Its object is to bring the deformed hallux and first metatarsal bone back to their normal positions and functions

HAUSER'S TECHNIC. I have devised the following operation an elliptical incision dorsal to the callus is made through the skin. The skin is reflected away from the bursa which is dissected free and removed (Fig 53) The abductor hallucis is identified and the tendon dissected free and divided at its insertion At a later stage in the operation it is transplanted to the base of the first phalanx on the medial side, more dorsal than its original point of insertion Next the shortened adductors and the contracted lateral side of the capsule are divided Occasionally this is done after exposure through a dorsal incision between the first and second toes. In some instances it is adequate to tenotomize subcutaneously To divide the lateral side of the capsule, it may be preferable to go through the joint with a strong tenotome (Silver) If the second incision has been carried out it is much simpler to divide the capsule from the lateral side.

It is sometimes necessary to cut through the shortened fascial strands on the lateral side of the toe In one instance it was necessary to free the contracted skin in this area

When the contractures are removed, it is possible to bring the great toe into normal alignment and remove whatever part of the head of the metatarsal bone projects on the medial side. It is best to remove enough so that the toe can easily be brought into hallux varus With the toe in varus position the capsule is sutured. After the abductor hallucis tendon is transplanted, with the toe in its new position the skin is closed.

If this type of operation is to be effective, it is necessary to restore the normal mechanical relations of the foot This means that the heel is brought into varus and the medial side of the anterior part of the foot is brought into pronation This position is held by a plaster of paris cast. The patient is permitted to walk on the cast as soon as the wound is healed usually seven to fourteen days after the operation

To prevent swelling and allow early weight bearing, the Unna paste boot is used to good advantage. After this the patient continues to wear the corrective shoe In every instance patients have worn the corrective shoe before operation In this way the maximum amount of correction is obtained by conservative means and there

is partial restoration of muscular strength before the operation is performed which simplifies the operation and shortens the convalescence. In some instances where the hallux valgus is present without appreciable pes valgoplanus the cast may be omitted. With the foot corrected and normal gait reestablished there is no longer any tendency toward recurrence (Figs 54 55 and 56)

KELLER S TECHNIC. Keller devised a technic to reduce the frequency of recurrence of the deformity and to prevent alteration of the normal arch

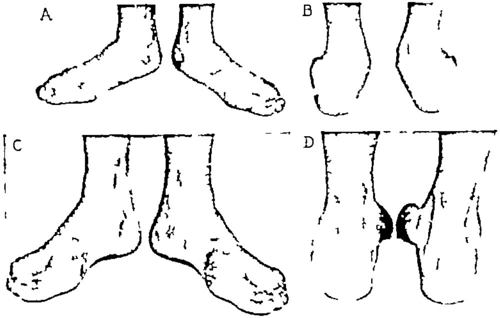


Fig. 54 Bilateral pes valgoplanus with hallux valgus A. Anterior aspect. Note the pronation with loss of arch and hallux valgus with prominence of the head of the first metatarsal bone B Posterior aspect Note the valgus position of the heel C Same feet after operation, anterior aspect. Note the presence of the arch and the correction of the deformity of the great toe D Posterior aspect after operation Note the normal position of the heel

Through a medial incision over the first metatarsophalangeal joint he removed the exostosis on the head of the metatarsal bone. The attachment of the flexor hallucis was freed with the periosteum from the base of the first phalanx. Then the base of the phalanx was removed

MCBRIDE S TECHNIC. McBride uses an incision over the lateral side of the toe to prevent a scar which may come in contact with the shoe Through this incision he is able to remove as much of the external surface of the bone as is necessary and also to shorten the

capsule. He divides the insertion of the adductor hallucis and trans plants it to the head of the metatarsal bone. The shortened capsule

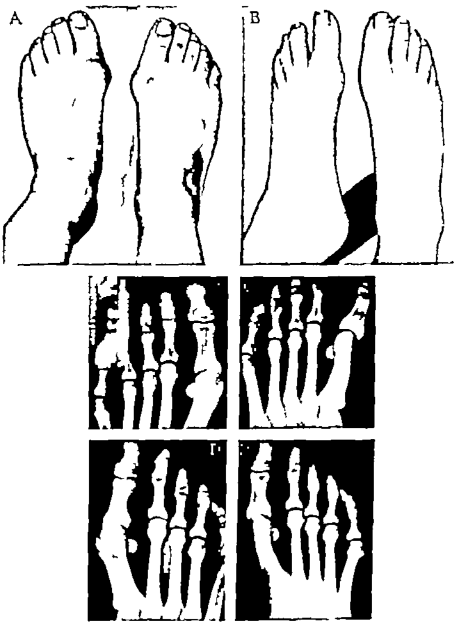


Fig. 55 Hallux valgus corrected by author's operation. *A*, Feet before operation. *B* feet after operation *C* roentgenograms of left foot before and after operation *D* roentgenograms of right foot before and after operation (Roentgenograms from S Clin North America vol 18)

is also divided He also recommends removal of the lateral sesamoid from the flexor tendon

PEABODY'S TECHNIC. Peabody uses a similar procedure but removes the wedge closer to the head of the metatarsal bone and also



Fig. 56 Hallux valgus in an older woman, corrected by the author's operation A, Before operation, *B* after operation *C* Roentgenogram before operation *D* after operation

excises the medial side of this bone Two small drill holes are made on each side of the osteotomy wedge to be removed Chronic

catgut passed through these drill holes fixes the position of the corrected metatarsal bone.

HISS TECHNIC. Hiss carries out an operation in which he emphasizes restoration of the tendon balance by means of surgery. He performs tenotomy of the adductor and then transplants the abductor muscle, suturing it to the head of the first metatarsal bone and the joint capsule. He also removes any osteophyte present on the medial side of the head of the metatarsal. At times he finds lateral capsulotomy necessary. He also performs interphalangeal skin lengthening. Occasionally he removes the lateral sesamoid bone and at times divides the extensor hallucis brevis in order to lengthen it. He has emphasized the fact that no set orthodox technic will cope with all varieties of hallux valgus.

LAPIDUS TECHNIC. Lapidus describes a procedure in which he resects the lateral side of the first cuneiformo-metatarsal joint to correct the abduction of the first metatarsal bone. The adjacent part *of the base of the second metatarsal bone is roughened with a curette,* and the exostosis of the head of the first metatarsal bone is removed.

HOHMANN'S TECHNIC. The exostosis on the medial surface of the *head of the first metatarsal bone is removed. A wedge osteotomy* is executed behind the head of the first metatarsal bone. The base of the wedge from the head of the first metatarsal bone is removed. *A wedge osteotomy is executed behind the head of the first metatarsal bone.* The base of the wedge is 0.5 to 1 cm in width. Shortening the metatarsal bone obviates contracture of the tendons and muscles so *that correction of the toe is accomplished easily.* The distended lateral surface of the capsule is attached to the periosteum of the first metatarsal bone and thus holds the correction during the operation.

The position of the head of the metatarsal bone after the osteotomy is important: the head of the first metatarsal bone is displaced plantarward and *medially. To accomplish this, the base* of the wedge lies plantarward and medially. The abductor hallucis is then transplanted to the medial side of the first metatarsal bone. After closure, Hohmann uses arch supports, massage and exercises to correct the existing pes valgoplanus.

Surgical Treatment (Radical) INDICATIONS. The indications for radical operation are limited to those patients who *have* a severe deformity in which the hallux valgus is extreme, the pes valgoplanus complete, and when conservative correction is not possible because of the patient's age or fixation of the joints. *In other words,* in the presence of an existing pes valgoplanus which cannot be cor-

rected, the head of the first metatarsal bone no longer carries out its normal function Its removal, therefore will not impair function or increase symptoms The procedure is simple and the result satisfactory The patient is relieved of the inflammation and irritation and the appearance of the foot is improved If these criteria for radical operation are not followed, this type of surgery gives rise to secondary complications which have brought the entire surgical procedure for hallux valgus into relatively bad repute The incomplete pes valgoplanus with removal of the head of the first metatarsal bone suffers a greater decompensation and increase in symptoms. These symptoms are not relieved until the pes valgoplanus has become complete which may take many months If the pes valgoplanus is incomplete, there is the possibility of recurrence of the hallux valgus even after operation since the causative factors are frequently not removed and the hallux valgus increases If the function of the great toe is lost as a result of improper surgery, more weight bearing is shifted onto the heads of the second and third metatarsal bones, with an increase of symptoms in this area

TECHNIC The radical operation is carried out through a curved incision on the medial and dorsal border The bursa is exposed. If it shows signs of chronic inflammation which is usually the case, it is dissected carefully and removed The head of the first metatarsal bone is then resected This is done by means of a large, double jointed Stille bone-cutting forceps or with an osteotome If the osteotome is used the bone is encircled with two curved periosteal elevators This will prevent injury to the soft tissues on the lateral side. After resection the margins of the distal end of the metatarsal bone must be made smooth no projecting spicules are allowed to remain If there is sufficient capsule, the distal end of the metatarsal bone may be covered with the capsular tissue. The toe is easily brought into normal position owing to the shortening of the metatarsal bone. The remaining part of the lateral side of the capsule is fastened to the metatarsal bone to retain the corrected position A slight amount of overcorrection in varus may be held temporarily

Care must be exercised to have the toe in the midposition and not in dorsiflexion The wound is closed and the foot bandaged with the great toe held in varus The foot is kept at rest until the wound has healed entirely An Unna paste boot is than applied to prevent swelling Since it is not necessary to direct any correction against the pes valgoplanus deformity the patient s ordinary shoes may be worn

OVERLAPPING TOES

In extreme cases of hallux valgus the great toe overlaps the second toe This deformity may be so severe that the great toe turns outward at a right angle, overlapping the others at their bases (Fig. 57)

Treatment The treatment for this overlapping toe consists in correction of the deformity by resecting the base of the proximal



Fig 57 Marked hallux valgus, showing the great toe overlapping the second and third toes

phalanx. This can be executed under local anesthesia after the manner of Brandes (Fig 58)

A curved dorsal incision is made to expose the extensor hallucis longus tendon sheath The sheath is opened and the tendon is displaced laterally The medial side of the head of the metatarsal bone is exposed The exostosis and the part of the head that projects beyond the plane of the shaft of the first metatarsal bone are then removed A thin osteotome is placed at the base of the head of the first metatarsal bone, parallel to the shaft and driven up into the joint The medial fragment is then everted from the joint capsule and excised from its attachment The joint capsule is opened so that the base of the first phalanx can gradually be lifted out by means of a periosteal elevator Then with a Stille bone-cutting forceps the proximal third of the proximal phalanx is resected The remainder of the phalanx is rounded and made smooth. After hemostasis the capsule is closed The extensor hallucis is allowed to fall back into

place and the skin is closed The toe is held in slight plantarflexion and abduction.

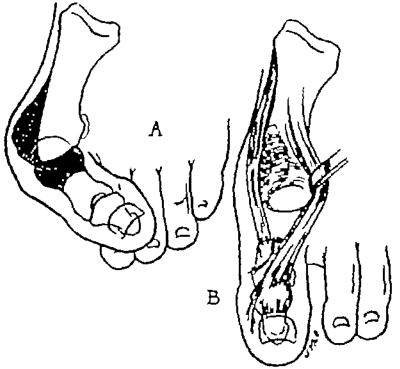


Fig 58 Correction of extreme hallux valgus A. Shaded areas show parts of bone removed *B* Transplantation of abductor hallucis to proximal phalanx

A plaster of paris cast or starch bandage may be applied to hold this position Heat and massage are used to reestablish normal mo-

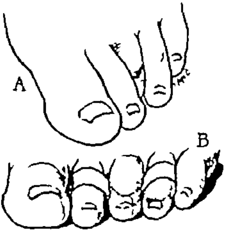


Fig. 59 A. Undertoe deformity *B* Adhesive strapping used for correction

tion Weight bearing is started after two weeks, and the amount of walking is increased gradually

When overlapping occurs in toes other than the great toe, treatment is directed toward the toe that is overlapped The underriding toe is brought into normal position and held there by means of adhesive tape. The tape is attached to the toes on either side, forming a sling under the involved toe to hold it in the normal position (Fig 59)

HALLUX RIGIDUS

Hallux rigidus is a flexion deformity of the great toe in which there is limitation of motion at the metatarsophalangeal articulation It is recognized in its developed form chiefly in adult life; it may however occur during the adolescent period

Etiology The condition is the result of traumatic irritation A direct blow which strikes the metatarsophalangeal articulation may give rise to the condition This area is subjected to strain by jumping from heights climbing hills or ascending stairs Excessive strain for a prolonged period will ultimately set up a traumatic irritation In a similar manner strain is exerted at this point as a result of wearing high-heeled shoes The abnormal gait associated with a stiff-shanked shoe and high heels increases the trauma to the metatarsophalangeal articulation The same causative factors that bring about hallux valgus namely the altered mechanics of the foot secondary to pes valgoplanus may give rise to hallux rigidus

When hallux rigidus rather than hallux valgus occurs in cases of traumatic irritation it is due to the strength of the capsule, ligaments and the abductor hallucis During adolescence the epiphyses at the heads of the metatarsal bones are soft and susceptible to injury Repeated trauma will set up an inflammation and if the condition is allowed to continue, the epiphyses will show alterations similar to those seen in the hip in Perthes disease. The epiphysis may show separation and ultimately some flattening it becomes disklike. In the early phases there are no roentgenologic changes However there is limitation of motion at the metatarsophalangeal articulation due to a reflex muscle spasm With the flattening of the epiphysis there is a loss of joint space, and projections are gradually observed extending along the joint margin Repeated irritation as a result of continuance of trauma increases the overgrowth until there may be an interlocking of exostoses from the head of the metatarsal bone to the first phalanx, with complete fixation of the toe

A similar type of arthritic change is seen in cases in which the trauma in this region is combined with a gouty diathesis

Symptoms. The chief complaint is pain on the dorsum of the

head of the first metatarsal bone The shoe rubs at this site. Pain is increased with movement at this articulation Any attempt at normal walking is painful. Usually the patient walks on the outer side of his foot with resultant overstrain and symptoms of pressure at the heads of the metatarsal bones particularly the third fourth and fifth Painful calluses may develop on the plantar surface under the head of the fifth metatarsal bone At the same time a painful callus may develop on the dorsum of the great toe, or on its lateral surface and occasionally even on the plantar surface where weight bearing occurs Pressure over the dorsolateral area may cause extreme pain Irritation may result from a friction rub against the shoe. Pain is increased in going up hill or walking up and down stairs

I have observed instances in which the nerve was caught by the exostosis in this area

The most characteristic symptom is a limitation of movement at the metatarsophalangeal articulation At the same time the toe is usually in plantarflexion Dorsiflexion is limited, and an attempt to bring the great toe into dorsiflexion meets with contracture resistance. Plantarflexion is also limited The limitation of dorsiflexion hinders the normal rolling gait, since the foot must be externally rotated and the weight is rolled off the medial side of the great toe. Calluses develop in the region of the head of the first metatarsal bone as well as on the skin over the base of the great toe. Roentgenograms show loss of joint space, and exostoses on the articular margins. These may appear as spicules or as sharp hooks The overgrowth is easily palpable under the skin

The condition is not associated with a generalized infectious arthritis in other joints, nor is there present the punched-out area seen in gout. The exostoses and loss of joint space are much more extreme than is sometimes seen in the late stages of hallux valgus

Treatment. *Prophylactic Treatment* In adolescence the application of a plaster of paris cast to put the foot at rest and at the same time to correct any pes valgoplanus will result in subsidence of the reflex muscle spasm and reestablishment of normal motion After this has been accomplished treatment is continued by means of the corrective shoe with a supinating heel and transverse bar as described under the treatment of Pes Valgoplanus

Conservative Treatment Conservative treatment for the adult may be used in beginning or mild cases, or in severe cases where age is a contraindication to operation In the early or mild cases correction of the pes valgoplanus by means of the corrective shoe may give complete relief from symptoms To abet these corrective

measures of the shoes, heat and massage are used. Strain is avoided until all inflammation has subsided Once sufficient motion can be reestablished at the metatarsophalangeal articulation to permit normal gait, further development of the condition can be prevented

In advanced cases where surgery is contraindicated, much benefit may be obtained by the application of a transverse bar on the shoe or better by the use of a raised mound under the heads of the middle metatarsal bones This gives a roller effect which makes it easier to walk. In severe cases when standing is painful a support

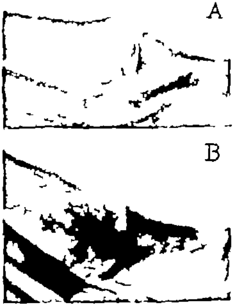


Fig 60 Hallux rigidus corrected by the author s operation A, Roentgenogram before operation, B after operation

may be placed under the area of the first metatarsal bone. This raise may be applied inside the shoe. In this way the head of the metatarsal bone and the first toe are relieved of weight bearing The steel arch support may be molded according to a plaster of paris model in order to take the weight off the first metatarsophalangeal joint

In all cases in which the overgrowth is allowed to remain the upper of the shoe must be adjusted accordingly The leather should be soft and stretched sufficiently to avoid any pressure

Operative Treatment Operative treatment consists first in a dorsomedial incision with exposure of the short thickened capsule The digital nerves are then identified and retracted The dorsal exostoses are removed with a thin osteotome and the lateral ex

ostoses are removed with a curved chisel (Fig 60) If the bursa shows signs of chronic inflammation, this is also excised.

In relatively mild cases this amount of surgical treatment may suffice, although in most instances it is advisable to remove the proximal part of the proximal phalanx.

When there is a tendency toward valgus of the first metatarsal bone, it is advisable to transplant the adductor hallucis dorsally to fasten onto the shortened first phalanx, or a section of the base of the first phalanx, to which the abductor hallucis is attached, may be transplanted and fixed into the head of the first metatarsal bone so that the abductor hallucis will correct the valgus position of the head of the first metatarsal bone. In some instances contracture of the plantarflexors is extreme, so that resection of the base of the first phalanx will not suffice to allow resumption of normal dorsiflexion of the toe. In this case it is necessary to divide both heads of the flexor hallucis brevis If flexion is not possible even then, the fixed sesamoids are mobilized by division of the cartilaginous plate between the two

After operation the foot is kept at rest for about two weeks after which weight bearing may be resumed gradually At first, stiff shanked shoes are worn in which felt pads have been placed under the longitudinal arch and posterior to the transverse arch Motion is then gradually gained by means of hot applications followed by massage. Active motion without weight bearing is encouraged as soon as the pain subsides sufficiently In this way enough motion is reestablished to permit normal gait. The corrective shoe, as described for the treatment of Pes Valgoplanus is then utilized to restore the normal gait.

HALLUX FLEXUS

Hallux flexus is a contracture deformity with plantarflexion of the great toe.

Etiology The condition may occur secondary to talipes cavus as the result of traumatic inflammation in the region of the sesamoids or secondary to pes valgoplanus. The last is the most frequent cause.

Hallux Flexus Secondary to Talipes Cavus (Hallux Malleus) In the flexion deformity secondary to talipes cavus the situation is practically the same as in hammer toe Here the proximal phalanx projects dorsally forming an angle at the metatarsophalangeal articulation Frequently there is a subluxation at this joint There is also an angle at the interphalangeal articulation with the distal phalanx either extending straight or projecting downward As a result of the

deformity the great toe does not touch the floor The angulation at the interphalangeal articulation causes friction rub against the shoe. Calluses may arise here. The head of the metatarsal bone, as well as the rest of the ball of the foot receives excessive weight

Treatment In most cases correction of the talipes cavus will improve the position of the toe sufficiently to relieve the symptoms Occasionally however the contracture is firm enough to resist correction even after the obliteration of the cavus deformity of the foot. In this case the operation described for the correction of hammer toe may be done.

Hallux flexus is also corrected in the same manner as described for the treatment of talipes cavus by correcting the cavus deformity and then transplanting the extensor hallucis longus into the head of the first metatarsal bone. The extensor hallucis longus has also been transplanted into the base of the first phalanx, with a satisfactory result in respect to correction of the flexion deformity of the hallux

Hallux Flexus as the Result of Traumatic Inflammation in the Region of the Sesamoids. Hallux flexus resulting from trauma in the region of the sesamoids is a true contracture deformity with limitation of motion in the metatarsophalangeal articulation The sesamoids are displaced proximally and are altered in shape. They may be divided or decreased in size The sesamoids may become attached to the plantar surface of the first metatarsal bone.

Treatment Prophylactic treatment consists in the prevention of scar tissue after trauma Protection is necessary until the inflammation has subsided otherwise, contractures and a flexion deformity of the great toe will result. In early cases corrective treatment consists in manipulation which will gradually stretch the contracted tissue by slowly bringing the toe into dorsiflexion After manipulation the overcorrected dorsiflexed position is retained by means of a cast As soon as the pain subsides the cast is removed and heat and massage are started at the same time active motion is encouraged

In a fixed contracture operative intervention is usually necessary This consists in removal of the sesamoid bones The digital nerves are identified as they pass under the plantar aponeurosis on the flexor hallucis brevis muscle. The skin aponeurosis and nerves are drawn aside The tendon sheath of the flexor hallucis longus is split lengthwise and the tendon is pulled down out of the way Then the medial sesamoid is encircled with a scalpel. The same is done to the lateral sesamoid and if this is not sufficient the fibrous tissue which connects the two is divided permitting dorsiflexion of the toe

Hallux Flexus Secondary to Pes Valgoplanus. Hallux flexus deformity has been observed in association with pes valgoplanus In these cases the great toe is plantarflexed with an angulation at the metatarsophalangeal articulation At the same time the first metatarsal bone is in a dorsiflexed position with an angulation at the tarsometatarsal articulation This altered position of the first metatarsal bone gives rise to supination of the anterior part of the foot. Furthermore, there is pronation in the tarsal area and the heel is in valgus position

In the first cases to be described in the literature the condition was of long standing In these cases the deformity of the great toe was most evident and for this reason was interpreted as the primary deformity The condition is invariably associated with pes valgoplanus and supination of the first metatarsal bone. The condition has been described in the adolescent period where the pes valgoplanus had existed from early childhood

The present interpretation of this deformity is that the pes valgoplanus and the dorsiflexion of the first metatarsal bone occur first. To accomplish weight bearing, the great toe reaches for the floor and gradually assumes a contracted position Unless the condition is corrected the flexion of the great toe progresses

The chief symptom of the disorder is a severe contracture of the first toe in which the head of the metatarsal bone projects dorsally and the tip of the toe touches the floor The deformity may be so severe that the toe is at a right angle. There is some subluxation at the metatarsophalangeal articulation Frequently the four lateral toes show some sign of contracture. The patient walks with a flatfooted gait.

Treatment Treatment is directed against the pes valgoplanus and is carried out in the manner described under the treatment of that condition In mild cases this will relieve the flexion contracture of the great toe. In more extreme cases manipulative correction is carried out under anesthesia The great toe is extended and brought into dorsiflexion at the metatarsophalangeal articulation When the contractures are firm the capsule and lateral ligaments are divided. At the same time the preexisting supination of the anterior part of the foot and valgus of the heel are corrected by manipulation The correction is maintained by a plaster of paris cast

When the deformity is extreme and there is a subluxation with a firm contracture the base of the first phalanx is resected and the toe can then easily be brought into a straight position

HALLUX VARUS

Hallux varus a relatively rare congenital deformity is frequently associated with an anomaly of the bones of the great toe, usually with polydactylism or syndactylism Most of the cases are unilateral and show anomalies in other parts of the body Individual cases have been described in which the condition was apparently due to a postural disturbance in utero

Treatment The treatment is operative and consists in removal of the extraneous bone. When a double toe exists one can be removed

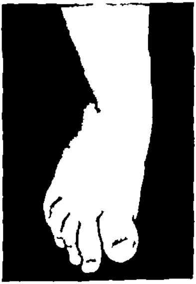


Fig 61 Congenital hallux varus.

by extra articulation Deviation of the great toe can be corrected by means of an osteotomy through the first metatarsal bone. In those cases in which there is no congenital anomaly, if seen soon after birth, fixation of the toe in an overcorrected position will result in gradual correction of the deformity (Fig 61)

Congenital hallux valgus is rare the treatment is similar to that for congenital hallux varus (Fig 62))

HAMMER TOE

This is a condition in which the proximal phalanx of a toe is extended while the second and distal phalanges are flexed causing a clawlike appearance The second toe is most often involved The condition may be congenital or acquired Congenital hammer toe usually affects the second toe acquired hammer toe is practically

always secondary to some other deformity, such as pes valgoplanus or talipes arcuatus

Congenital Hammer Toe. Congenital hammer toe is observed as a mild deformity in early childhood With walking the deformity is increased The flexion contracture may become fixed, the capsule shortened at the interphalangeal articulation, the tendons and skin contracted and the proximal phalanx project dorsally to form an angle with the second phalanx On the dorsum the friction rub causes



Fig 62. Congenital hallux valgus in a child

a callus, and beneath this callus is a bursa which may become inflamed from time to time (Fig. 63) A painful callus frequently forms as the result of friction on the tip of the toe underneath the nail.

Treatment When seen in early childhood the deformity is remedied by correcting the extension of the proximal phalanx and by straightening out the flexed distal phalanges To accomplish this a felt pad about 1/4 inch thick is fastened over the dorsum of the proximal phalanx by means of a narrow strip of adhesive. The distal phalanges are held in extension by fastening a felt pad underneath the interphalangeal articulations with a strip of adhesive

tape The toe may also be held in extension by fastening it to a small metal splint Repeated manual manipulation of the toe is of some value. When the child begins to walk, a metatarsal bar applied to the shoe, posterior to the heads of the metatarsal bones, will tend to stretch the flexor muscles of the contracted toe.

In cases in which the contracture has been fixed operative correction is the method of choice. Under local anesthesia the bursa is removed through a dorsal incision and the extensor tendon is divided The proximal phalanx is exposed and with the bone-cutting



Fig 63 Hammer toe, showing contracture and dorsal callus.

forceps the distal end is divided and removed It is extra-articulated at the interphalangeal joint Sufficient bone is removed to allow easy correction of the deformity If the deformity is severe the entire proximal phalanx may be removed The extensor tendon is then sutured shortening it to allow for the resection This retains the corrected position

The callus may be removed before the closure The extensor tendon may be split and the operation carried out as previously described, shortening the tendon by reefing (Fig 64) Resection of the joint with ankylosis leaves a stiff awkward toe

Removal of the toe is not justified and tenotomies are inadequate even though followed by manipulation and a cast

Acquired Hammer Toe. Acquired hammer toe is essentially the

same as severe contracture of a toe. In pes valgoplanus the contracture is due to the stretching of the plantar aponeurosis to which the short flexor muscles are attached. The insertion of the short flexor tendons is in the distal phalanges These are flexed while the proximal phalanx has a tendency to extend

In talipes cavus the extensors of the toes are under tension and all the toes, including the first are contracted If this position is not corrected, the plantarflexors shorten and the plantar aponeurosis

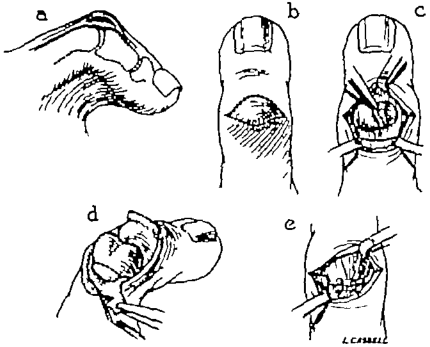


Fig. 64 Author's operation for hammer toe. A, Hammer toe with inflamed bursa and soft tissue contractures B lateral oval incision C removal of the bursa and division of the extensor tendon, D resection of the head of the proximal phalanx, E closure with shortening of the tendon

becomes thickened and contracted forming a contracture of the toes If the contractures are severe the toe will subluxate at the metatarsophalangeal articulation and the head of the metatarsal bone will be forced downward As a result there is increased pressure with the formation of painful calluses on the ball of the foot

In many cases the pain under the heads of the metatarsal bones will be the source of the most serious complaint. The dorsally projecting toes with the distal phalanges flexed will give rise to calluses on the dorsum and end of the toe as described in Congenital Hammer Toe.

The presence of a contracture over a long period will involve not

only the tendons but also the capsule and lateral ligaments of the metatarsophalangeal and proximal interphalangeal articulations

Treatment Prevention of contractures of the toes can be accomplished by instituting early correction of the pes valgoplanus by means of a shoe with the corrective heel and transverse bar In mild cases the contracture will respond to this type of treatment the symptoms will be relieved and the toe restored to its normal form The corrective shoe is also used in severe cases

The shoe is worn for brief periods of time each day Felt pads are used to prevent friction rub on the dorsum as well as on the end of the toe A felt pad ¼ to ½ inch thick is placed over the

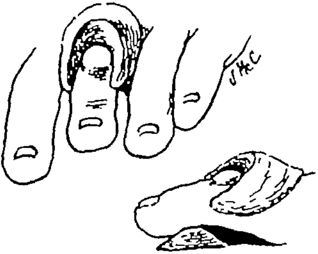


Fig. 65 Pads used in relief and correction of a hammer toe The dorsal pad is placed behind the callus. The volar pad causes extension of the contracted terminal phalanges

dorsum of the proximal phalanx of the toe involved. To prevent friction rub at the end of the toe the distal phalanges are extended and a felt pad is fastened to the plantar surfaces of the toes (Fig. 65)

In a firm contracture, attempts at conservative correction by means of alterations on the shoe will be unsuccessful. An attempt to stretch the shortened muscles will force the proximal phalanx into further extension and cause increased friction rub on the dorsum of the toe When relief cannot be obtained by forcing the proximal phalanx downward with a felt pad, surgery is necessary

Operative correction consists in resection of the distal end of the proximal phalanx, as in congenital hammer toe. In cases wherein correction is impossible, some relief may be obtained by resecting the base of the proximal phalanx This relieves the pressure of the head of the metatarsal bone against the floor

When operation is abnegated the severe forms of hammer toe

can be alleviated by the application of felt pads to the toes Mild correction can be obtained by the use of heat, followed by massage and manual manipulation As the contractures become looser further correction may be secured by using the corrective shoe In this way sufficient relief can be obtained to enable patients of advanced years to carry out normal function comfortably The dorsal projection of the contracted toe requires more space than the ordinary shoe



Fig. 66 Bilateral digiti quinti varus, congenital, worse on right than on left.

allows For this reason, a soft leather shoe with an expansive upper in the anterior part is required When necessary an opening can be cut in the shoe over the deformed toe and a soft leather patch applied to cover this opening

DIGITI QUINTI VARUS

Digiti quinti varus is a congenital malposition in which the fifth toe overlaps the base of the fourth This deviation is associated with some rotation At times the adducted fifth toe may overlap and fall into a groove so that it fits without giving rise to symptoms The condition may occur bilaterally and there seems to be a familial tendency (Fig 66)

Symptoms The deformed toe is subjected to pressure and friction rub which result in the formation of a painful corn. From time to time the toe becomes inflamed. In this condition the fifth toe is underdeveloped and is smaller than normal Sometimes the head of the fifth metatarsal bone is drawn away from the head of the fourth, so that there is a subluxation at the metatarsophalangeal joint.

Treatment. When the deformity is seen in early childhood correction is attempted by manual manipulation of the foot into the normal position which is then held by means of adhesive plaster A felt pad may be placed on the dorsal and medial surfaces of the fifth toe, forcing it laterally and downward

Digiti quinti varus can be corrected by means of an operation in which the shortened medial side of the metatarsophalangeal joint capsule is divided The toe is brought into abduction the lateral side of the capsule is reefed and shortened and the toe is held in plantarflexion and abduction by suturing the distal end of the abductor digiti quinti to the lateral side of the proximal phalanx (Hohmann) Where the digiti quinti varus is of long standing, or in the case of older patients disarticulation at the metatarsophalangeal joint will give relief of the local symptoms

A similar congenital deformity sometimes involves the third and fourth toes It is usually not so severe, but the same principles of treatment may be applied as were described for digiti quinti varus

TAILOR'S BUNION

The fifth toe is prone to contracture deformity This toe is apparently undergoing retrogression and frequently has but two phalanges. When this is the case, it is due to the absence of the middle phalanx. All the structures of the toe are underdeveloped This toe has a tendency to contract and is more exposed to friction rub than the others. These retrogressive signs in the fifth toe indicate its minor functional importance

The fourth and third toes are apparently also less important functionally than the first and second

There is a contracture of the fifth toe associated with metatarsus latus With spreading of the anterior part of the foot the head of the fifth metatarsal bone is separated away from the fourth There is likewise external rotation and dorsal displacement of the head of this metatarsal The fifth toe is displaced medially and is dorsiflexed at its proximal phalanx whereas the distal phalanges are plantarflexed

Symptoms. The angulation at the interphalangeal articulation is

subjected to pressure and friction rub and is the common site of a corn The displaced head of the fifth metatarsal bone projects laterally to encounter pressure from the shoe. Friction rub over this area gives rise to a callus on the skin and an inflammation of the bursa over the metatarsal bone. When the condition is of long standing, a chronic bursitis develops This bursa may become inflamed as the result of sitting cross legged on a bench, hence the so-called tailor s bunion

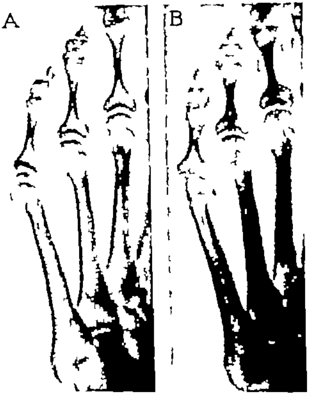


Fig. 67 Roentgenograms in a case of digiti quínti varus with bursitis in the region of the head of the fifth metatarsal bone. A, Before operation B, after operation.

Treatment Prophylactic treatment consists in the prevention of metatarsus latus When the deformity is so marked that it is impossible to wear the corrective shoe, surgical intervention is indicated

In some cases it is adequate to divide the contracted capsule on the medial side of the metatarsophalangeal articulation and reef the distended lateral side of this capsule, thus correcting the varus position of the toe. At the same time the toe is held abducted and plantarflexed by suturing the abductor digiti quinti dorsal to the lateral side of the proximal phalanx In mild cases the transplant

of this tendon will exert a force to correct the altered position of the head of the fifth metatarsal bone (Fig 67) In severe and chronic cases it may be necessary to remove the thickened bursa and at the same time, with a thin osteotome, to remove the part of the head of the metatarsal bone that projects laterally

Disarticulation of the fifth toe in an attempt to correct this deformity is usually unsatisfactory inasmuch as there is further displacement of the head of the fifth metatarsal bone and new pressure symptoms arise

CONGENITAL ANOMALIES

Syndactylism Syndactylism of the foot is of less clinical importance than syndactylism of the hand (Fig 68) The toes may

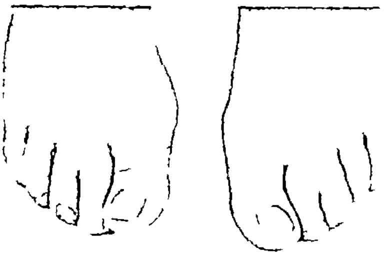


Fig 68 Bilateral syndactylism

be webbed by the skin alone, or the deeper structures may also be involved The fifth and first toes are most frequently affected There is a familial tendency in this condition

The deformity does not interfere with function however and the primary indication for treatment is for the cosmetic effect. The toes can be separated surgically An incision approximately 1 cm in length is made in the midline on the dorsum at the base of each of the involved toes The distal ends of these incisions are connected transversely and a full thickness flap raised with the base attached proximally The toes are then separated to their full extent by sharp dissection The distal end of the previously prepared flap is then sutured to the plantar surface of the foot forming the web between

the two toes The remaining raw surfaces are covered by free full thickness grafts from the thigh or abdomen Correction of this deformity is however rarely desired.

Polydactylism This is an infrequent congenital deformity The extra toes are usually found on the lateral side of the foot (Fig 69) They vary from small projections to a completely formed toe A small projection may be present at the side of the base of the first metatarsal bone, or there may be a division of the head of the first metatarsal bone or again there may be two separate series of bones for the great toe Usually there is but one extra toe, although cases have been described showing more (Fig 70)

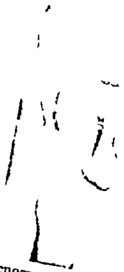


Fig 69 Roentgenogram showing polydactylism

The polydactyl foot requires a larger shoe than its mate. Frequently there are symptoms of friction rub in the area of the extra toe For this reason as well as for improvement in appearance, the toe may be removed Disarticulation at the proximal phalanx is usually sufficient

Underdevelopment or Absence of Toes One may encounter absence of a toe or an incompletely formed toe. The fifth toe is most often involved A case has been described in which the third metatarsal bone was incompletely developed. Another case was reported in which the fourth metatarsal bone failed to develop fully and was shorter than its neighbors This type of anomaly apparently results from some interference with the germ plasm or from an intra-uterine aberration Frequently the fifth metatarsal bone is underdeveloped In cases of appreciable shortening the condition is associated with

digiti quinti varus Sometimes the toes show congenital anomalies that are apparently intra-uterine amputations The interference with intra-uterine growth of the toes is seen sometimes in association with clubfoot

Metatarsus Calcaneus. A condition has been described in which there is a projection of bone along the base and on the lateral

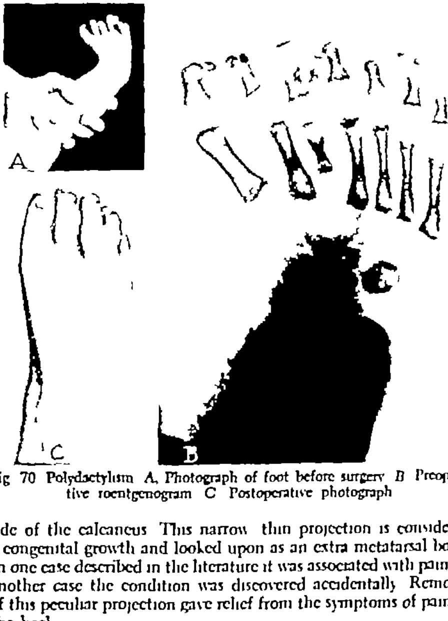


Fig 70 Polydactylism A, Photograph of foot before surgery B Preoperative roentgenogram C Postoperative photograph

side of the calcaneus This narrow thin projection is considered a congenital growth and looked upon as an extra metatarsal bone In one case described in the literature it was associated with pain in another case the condition was discovered accidentally Removal of this peculiar projection gave relief from the symptoms of pain in the heel

Giant Toe. Hypertrophy of an individual toe occurs occasionally so that it is out of proportion to the rest of the toes (Fig 71)

The great toe has been observed to be symmetrically increased in size on one foot, requiring a different-sized shoe for this foot as compared with its mate. A case has been cited in which the second and third toes were greatly increased beyond the size of the first

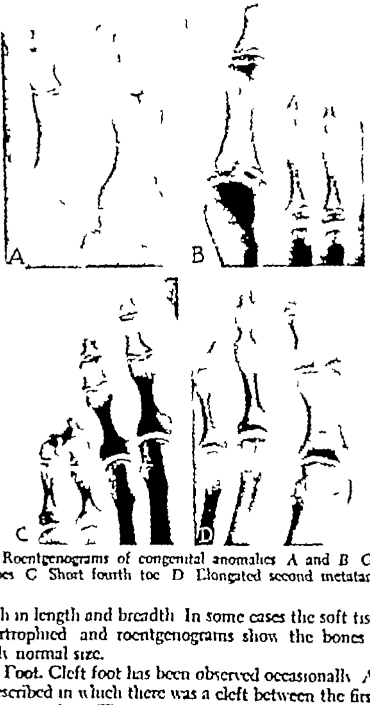


Fig 71 Roentgenograms of congenital anomalies A and B Giant great toes C Short fourth toe D Elongated second metatarsal.

toe, both in length and breadth In some cases the soft tissue alone is hypertrophied and roentgenograms show the bones to be of relatively normal size.

Cleft Foot. Cleft foot has been observed occasionally A case has been described in which there was a cleft between the first toe and the remaining four This suggests retention of the primitive foot.

I have seen a similar cleft between the second and third metatarsal bones with absence of the second and third toes

The function of this type of foot is good but for cosmetic reasons a correction of the deformity may be attempted The skin is reflected



Fig. 72 Cleft foot (Courtesy of Dr Beveridge H Moore)

from one side to make a dorsal flap and from the opposite side to make a plantar flap The metatarsal bones are then drawn together and the flaps are closed (Fig 72)

REFERENCES

Brandes, M Zur operativen Therapie des Hallux valgus Zentrabl. f Chir., 56 2434 1929

Girdlestone, G R., and Spooner H J A New Operation for Hallux Valgus and Hallux Rigidus J Bone & Joint Surg *19* 30, 1937

Hauser E. D W Surgery of Minor Foot Conditions S Clin. North America, *18* 85 1938.

Hiss J M Hallux Valgus, Its Causes and Simplified Treatment. Am. J Surg., *11* 51 1931

Hohmann, G Zur Hallux valgus-Operation. Zentralbl f Chir., *51*.230 1924
Keller W L. The Surgical Treatment of Bunions and Hallux Valgus New York M J., *80* 741 1904
Lake, N The Foot 2d ed New York, William Wood and Co., 1938.
Lapidus, P W Operative Correction of Metatarsus Varus Primus in Hallux Valgus Surg., Gynec & Obst. *58* 183 1934
McBride, E. D The Conservative Operation for Bunions J.A.M.A., *105* 1164 1935
McMurray T P Treatment of Hallux Valgus and Rigidus Brit. M. J., 2.218 1936
Silver D The Operative Treatment of Hallux Valgus J Bone & Joint Surg., *5* 225 1923

7

ORTHOPEDIC CONDITIONS OF THE ACCESSORY BONES

SESAMOID BONES

Sesamoid Bones Under the Heads of the Metatarsal Bones. Two sesamoid bones occur regularly under the head of the first metatarsal bone The medial one is larger than the lateral The ossification centers for these sesamoids do not appear until the ages of seven years in girls and ten in boys Once ossification begins it proceeds rapidly and is usually complete at the end of a year or at the most two years

There may be one or several ossification centers for each sesamoid bone These centers may fail to unite resulting in a division of the bones These divisions may be equal, or one fragment may be larger than the others At times the sesamoid may be tripartite or there may even be multiple segments (Fig 73)

The recognition of these normal divisions is significant inasmuch as they have frequently been mistaken for fractures Disease of these sesamoids is relatively rare Abnormalities that have been found are fracture of the single or divided sesamoid or traumatic arthritis of the sesamoid

Sesamoid bones are seen regularly under the heads of the fifth and second metatarsal bones Occasionally the sesamoid under the fifth metatarsal bone is double. Sesamoids are rarely seen under the heads of the other metatarsals

Fracture of the Sesamoids. There may be fracture of the single sesamoid or of the divided sesamoid. A diagnosis of fracture must be made with care It is necessary to establish the presence of a callus otherwise, histologic examination after the removal of the sesamoid bone would be necessary for convincing proof Further proof would be to have a roentgenogram taken before the injury and another after the injury showing the altered sesamoid

It is generally believed that the divided type of sesamoid bone is more likely to suffer fracture after trauma. The cause of fracture is usually a direct injury as the result of a fall from a height, the blow striking the sesamoid beneath the head of the first metatarsal bone. Injury can also occur as the result of sudden, forceful hyperextension of the great toe.

When a sesamoid bone is fractured each step will cause pain Hyperextension of the toe will be painful This pain is usually so severe that weight bearing on the head of the first metatarsal bone



Fig 73 Quadruple division of sesamoid bone

is avoided and the patient walks on the outside of the foot Of diagnostic aid is the sudden onset of these symptoms immediately after trauma

Treatment Treatment consists in rest until the acute inflammation has subsided Hot dressings may be applied Prevention of weight bearing over this area and fixation of the great toe are obtained by the application of a plaster of paris cast to which a walking caliper is attached This cast is worn for six weeks On removal of the cast the sesamoid bone is reexamined by roentgenogram for the presence of callus (Fig 74)

This is followed by the use of the corrective shoe to which a flat transverse bar is applied on the outside to take the weight off the region of the heads of the metatarsal bones The heel of the shoe

has a slight raise on the inner side which tends to throw the body weight on the outer side of the foot After a period of three to six weeks the shoe is altered so that the bar is higher on the outer than on the inner side The patient is then taught to contract the great toe in walking so that the ball of the toe receives most of the weight with a minimum amount over the head of the first metatarsal bone. Corrected gait is continued until there is no tenderness in the region of the sesamoid bone on normal walking

Only if the symptoms persist in spite of conservative treatment should removal of the bone be considered This can be carried out through a medial plantar incision The heads of the flexor hallucis

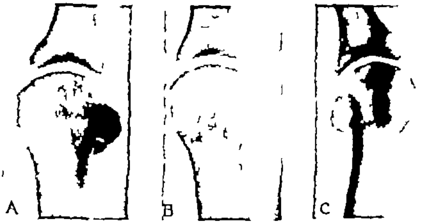


Fig 74 Fractured sesamoid. A, Roentgenogram of fracture B, healed sesamoid after author's conservative treatment C divided sesamoid for comparison

brevis are easily identified The fractured sesamoid is dissected free. Care must be taken not to injure the tendon since a division of the flexor hallucis brevis tendon will result in a hammer toe deformity It is not necessary to remove both sesamoids unless both are fractured.

Traumatic Arthritis of the Sesamoids. Traumatic arthritis is the most common disturbance of the sesamoid bones under the head of the first metatarsal bone. This is a painful condition localized to the sesamoid bones usually the medial one In most instances the injury is the result of repeated small blows such as occur in abnormal walking Constant pressure applied at this point is believed to set up a disturbance in the bones as well as in the surrounding tissue

The findings at the time of removal are inflammation in the tissue around the sesamoid bone, occasionally a small inflamed bursa

and changes in the sesamoid itself suggestive of a destructive process undergoing repair The condition is most frequently seen when undue pressure is exerted on the head of the first metatarsal bone in walking, owing to limitation of plantarflexion of the great toe For this reason it most frequently affects people who wear high heeled shoes or who dance on their toes such as ballet dancers

The chief symptom is pain localized over the area of the sesamoid bone. This area is tender to slight pressure Bringing the great toe into extension as in dorsiflexion increases the pain There is a tendency to shift the weight to the outer side of the foot so that the anterior part is in supination If this is continued over a long period, a supination contracture is brought about. The roentgenogram may show multiple fragmentation of the sesamoid bone.

Treatment Since this is an inflammatory disturbance and the result of trauma, rest is indicated An arch support constructed to remove the pressure over the sesamoid bones may be of some value in relieving the inflammation Local heat by means of hot applications allays the symptoms

With the heel held in varus by means of a Gibney bandage (Fig 177) the anterior part of the foot may be brought into pronation and fixed in this position with adhesive strapping. A semicircular felt pad is then placed around the area of the sesamoid bones to remove weight bearing from these bones Voluntary flexion of the great toe with each step is then encouraged If the great toe is free and can readily be brought down into plantarflexion, a transverse bar attached to the outside of the shoe will tend to remove the pressure from the head of the first metatarsal bone; the symptoms will gradually subside provided the great toe grasps the ground at each step In other words with the reestablishment of the normal position of the foot and normal gait, in which case weight bearing is taken over by the great toe, the cause of the condition is removed and a cure will be obtained

Since there is actual bony involvement however the period necessary for all symptoms to subside may be relatively long. The function of these sesamoid bones is to protect the tendon of the flexor hallucis longus which lies between them They act as pulleys since the weight bearing foot glides over them when walking and they give a better leverage for the flexor hallucis brevis They should therefore not be removed unless they are irremediably injured

Subluxation of the Sesamoids. The sesamoids are frequently subluxated This is a relative subluxation however since it occurs with an alteration of the position of the great toe, as in hallux valgus

In most cases the sesamoid bone will resume its normal position on correction of the underlying deformity

OS TRIGONUM

Of the inconstant accessory bones the most important is probably the os trigonum (Fig 75) This is a small fragment like bone which



Fig 75 Os trigonum

lies behind the posterior process of the talus and in immediate apposition to it It is circular or oval Because of its close apposition to the talus it is frequently mistaken for a fragment fractured from the posterior process of this bone.

In this connection it is well to remember that the posterior process of the talus is susceptible to injury and may be fractured The smooth border helps differentiate the os trigonum from a fracture of the tip of the posterior process The os trigonum which is attached to the talus may be forcefully separated from it and give

rise to painful symptoms If the os trigonum is entirely free, it may act as a loose body

Treatment. It may occasionally be necessary to remove the os trigonum, since it may interfere with motion and cause sharp pain while walking. The best approach to its removal is through a longitudinal incision in front of the lateral margin of the tendo achillis Through the fatty tissue, with the foot in plantarflexion the posterior margin of the talus and the os trigonum are exposed The accessory bone is then removed and the wound closed

OS NAVICULARE PEDIS

(*Os Tibialis, Accessory Scaphoid*)

This is a common accessory bone of the foot, it lies on the medial side of the navicular bone and in close contact with it (Fig 76)



Fig. 76 Os naviculare pedis (os tibialis accessory scaphoid)

It is easily recognized by roentgenogram and is frequently large enough to cause a projection medially and beneath the navicular bone When palpated it sometimes can be felt to slide over the smooth surface of the navicular bone Occasionally a sudden twist

or direct trauma will cause inflammation over this accessory bone. Symptoms of pain swelling and redness are observed

In children the condition is frequently associated with pes valgoplanus The symptoms usually arise after an injury The relation ship of the insertion of the posterior tibial tendon to this accessory bone is of some significance The posterior tibial tendon inserts by means of fibrous bands into the first cuneiform the first meta tarsal and sometimes even into the second and third metatarsal bones in addition to its main insertion into the navicular bone. The os naviculare pedis lies immediately under this tendon and tends to displace the attachments The interference in the tendon action



Fig. 77 Os vesalianum

decreases the efficiency of the muscular force and is said to be a factor in bringing about pes valgoplanus

Treatment When the os tibialis is so large that it repeatedly causes an inflammatory reaction its removal may be considered This accessory bone has been removed because of its part in causing flat foot in children

It is removed through a small medial incision and the tendon is transplanted to the plantar surface of the navicular bone thus increasing the efficiency of the muscle. In most cases the inflam mation in the region of the os tibialis will subside with heat and rest Recurrence can then be prevented by the corrective measures directed against pes valgoplanus bringing the heel into varus and the anterior part of the foot into pronation (See also Treatment of Pes Valgoplanus associated with os tibialis)

OS VESALIANUM

The os vesalianum lies proximal to and in contact with the base of the fifth metatarsal bone (Fig 77) It may unite with this bone to form a posterior projection Inflammatory reaction occurs at times, owing to irritation over the projecting area When seen in the roentgenogram, it has been mistaken for a fracture of the base of the fifth metatarsal bone, for it is difficult to distinguish it from an actual fracture



Fig 78 Os peroneum

The chief distinction is that a fracture is usually transverse, linear and complete with an irregular margin whereas the accessory bone is smooth and not entirely separated

Treatment. Usually no treatment is necessary If altered weight bearing causes irritation in the region of projection, the corrective shoe should be worn For symptomatic relief until this is accom plished, a felt pad fastened immediately posterior to the base of the fifth metatarsal bone has been found helpful Rarely is it necessary to remove the os vesalianum

OS PERONEUM

The os peroneum is a small inconstant, sesamoid like bone in the region of the peroneus longus tendon It usually lies in a groove where the tendon passes over the prominence of the cuboid Apparently it has no clinical significance (Fig 78)

OS SUBTIBIALE

The os subtibiale is a small accessory bone occasionally found at the tip of the medial malleolus. Since this is a common site of fracture identification of the accessory bone as such is important. It is recognized by its smooth margins. The presence of a similar condition in the opposite foot corroborates the diagnosis of os subtibiale.

SECONDARY CALCANEUS

The os sustantaculum tali or secondary calcaneus has been described as an accessory bone on the dorsal surface of the anterior



Fig. 79. Os intermetatarseum. (Courtesy of Department of P[illegible] Northwestern University Medical School.)

projection of the calcaneus. It lies between the calcane[illegible] cuboid and navicular bones. Irritation of this bone may ca[illegible] and the inflammation may result in fusion of the bone [illegible] navicular or the cuboid.

OS INTERMETATARSEUM

The os intermetatarseum is a small accessory bone lying [illegible] the bases of the first and second metatarsal bones. It is [illegible] attached to the second metatarsal bone and may be so w[illegible]

as to appear as an accessory metatarsal bone It is seen only rarely and does not give rise to symptoms (Fig 79)

OS INTERCUNEIFORME

The first cuneiform bone will be seen roentgenographically to be made up of several fragments These divisions are important only in that they are not to be mistaken for a fracture Otherwise, the condition is clinically unimportant

OS SUPRANAVICULARE

This is a small, triangular accessory bone, sometimes seen between the talus and the navicular bone It is usually attached to the navicular bone Since symptoms of static strain occur in this region it is important to be able to recognize the occasional appearance of this bone in order to distinguish it from an actual fracture of the navicular

TROCHLEAR PROCESS OF THE CALCANEUS

A projection of bone is occasionally seen on the lateral surface of the calcaneus, below the lateral malleolus This projection has the



Fig 80 Trochlear process of the calcaneus

appearance of an exostosis Anatomically however, it is said to arise from a separate epiphysis The significance of this projection is that, when present, the counter of the shoe will rub in this area and cause irritation and pain A special shoe is sometimes necessary to fit

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around the projection In case there is a valgus of the heel due to foot strain a large trochlear process of the calcaneus comes in contact with the tip of the lateral malleolus and causes pain in this region On correction of the valgus deformity of the heel and relief of the foot strain, the symptoms subside.

Treatment. Treatment consists in reestablishing the normal position of the heel The heel is first brought into varus by means of adhesive strapping and then held in normal position with the corrective shoe (Fig 80) Thus the presence of symptoms does not always necessitate removal

When repeated inflammation occurs over this area, it is best to remove the projection. This can be done through an incision over the peroneal tendon The peroneus brevis and peroneus longus tendons are then identified and displaced. The incision is carried through between these tendons until the bone is exposed and the projection is encountered The projection is then removed by means of a chisel, and the wound is closed

REFERENCES

Delano P J Os Intermetatarseum Unusual Variant. Radiology 37 102, 1941

Dwight, T A Clinical Atlas Variations of the Bones of the Hand and Foot. Philadelphia, J B Lippincott Co., 1907

Geist, E S The Accessory Scaphoid Bone. J Bone & Joint Surg., 7 570, 1925 Supernumerary Bones of the Foot—A Roentgen Study of the Feet of One Hundred Normal Individuals. Am J Orthop Surg., 12 403 1914

Kidner F C The Prehallux in Relation to Flatfoot. J.A.M.A., *101*:1539 1933

Mercer J The Secondary Os Calcis J Anat., *66*:84 1931

Milliken R. A. Os Subcalcis Am J Surg., 37 116 1937

Powers, J H Traumatic and Developmental Abnormalities of the Sesamoid Bones of the Great Toe Am J Surg., 23 315 1934

8

DISTURBANCES OF THE HEEL

CALCANEAL SPUR

The calcaneal spur is an exostosis which projects on the plantar surface of the calcaneus. It is easily recognized in a roentgenogram



Fig 81 Congenital elongation of the posterior process of the talus.

showing a lateral view of the heel (Fig 82)) The exostosis is associated with periosteal thickening and chronic bursitis

Etiology The constant pull of a fascial or muscular attachment to a bone frequently gives rise to a bony ridge or projection at the

site of attachment Such a ridge or projection may occur at the attachment of the plantar aponeurosis and short plantar muscles to the calcaneus In a chronic strain wherein the plantar aponeurosis is subjected to continued tension the projection is more pronounced. The ridge will be seen in a roentgenogram as a spurlike projection. These projections may appear during adolescence

In most instances such projections do not produce symptoms; they may however give rise to symptoms even at an early age. If the projection points downward and presses into the muscle tissue, it will act as a foreign body and cause pain on pressure. An inflammatory reaction may then occur in the region of the spur Since the projection is increased as a result of static strain it is frequently seen



Fig 82. Calcaneal spurs

in cases of extreme pes valgoplanus. The condition may also occur however in the presence of talipes cavus In cavus deformity an irritation occurs at the attachment of the shortened plantar aponeurosis which gives rise to an inflammatory reaction and spur formation. This same kind of spur if subjected to trauma may be fractured, but even if it is not fractured there will be an inflammatory reaction with painful symptoms Direct trauma is sometimes the cause of the spur This is possible, since trauma will set up an inflammation of the plantar surface of the calcaneus and the inflammatory reaction will ultimately lead to an excess growth of bone

The calcaneal spur is most frequently seen between the ages of forty and sixty years and is often associated with chronic arthritis and arteriosclerosis The arthritis may be chronic infectious gonorrheal or gouty In the presence of arthritis irritation of the calcaneus may give rise to chronic periostitis bursitis or calcaneal spur The inflammation is due to infection and mechanical irritation as a result of static disturbance

Symptoms. The symptoms are due to the inflammatory reaction rather than to the actual presence of the exostosis There is pain over the heel on weight bearing This is increased after prolonged standing and walking, particularly on hard floors The foot is painful on weight bearing after prolonged rest, the more so if there has been a strain on the previous day When walking is resumed, the pain in the foot gradually decreases until it is again subjected to strain when intense pain recurs The gait is altered in an attempt to protect the heel so that more weight bearing is placed on the anterior part of the foot At first the pain seems to be in the region of the spur but if prolonged walking and standing are continued, the entire heel may become painful and tender Frequently the condition occurs bilaterally, and the spur on one foot may be symptom free, whereas that on the other foot may be painful Deep pressure over the plantar surface of the heel in the region where the triangular plantar aponeurosis inserts causes exquisite tenderness This is usually localized to a small area The medial side of the calcaneus is sensitive to pressure; sometimes the entire heel is tender

A roentgenogram of the foot in the lateral view reveals a definite exostosis The projection is usually pointed and directed anteriorly Occasionally it has a plantar inclination The roentgenogram suggests that the projection is spearlike; actually it has a relatively broad base, and its margin may be irregular or smooth The periosteum in the region of the spur may be thickened The posterior margin of the calcaneus may be roughened, with small projections in the region of the insertion of the tendo achillis

In most cases the condition is associated with signs of foot strain and an actual pes valgoplanus is not uncommon

Treatment. The treatment at least primarily is not operative removal In view of the etiology and pathology treatment is directed first against the inflammatory reaction of the periosteum on the plantar surface of the heel and toward removal of the factors that cause the inflammation

Treatment of the inflammation itself consists in keeping the foot at rest, applying heat elevating the foot and sometimes light massage. Weight bearing is avoided as much as possible The heel is protected by placing air blown sponge rubber about ½ inch thick, in the heel of the shoe. This raises the heel and tends to shift the body weight anteriorly on the foot at the same time it acts as a cushion to protect the irritated tissue of the inflamed heel.

Since the primary causative factor is tension on the plantar aponeurosis and on the short muscles that attach to the calcaneus

lessening of this tension will bring relief This can be accomplished by the utilization of adhesive strapping. With the heel in varus, a Gibney bandage is applied The anterior part of the foot is then brought into pronation by forcing the head of the first metatarsal bone downward This position is held by means of adhesive tape (1 inch wide) attached to the dorsum of the anterior part of the foot and drawn around the medial border over the plantar surface, then up over the lateral border, and fastened below the medial malleolus This is repeated with a second strip of the adhesive tape. Both the medial and lateral margins are protected by a double layer of sheet wadding Sheet wadding is also utilized to prevent compression of the dorsal artery Bringing the heel into varus and the anterior part of the foot into pronation relaxes the short plantar muscles and the plantar aponeurosis

This same procedure can perhaps be executed in a much more satisfactory and simple way by means of the supinating heel and pronating transverse bar applied to the shoe. The use of this type of correction occasionally results in immediate relief In most instances the symptoms are definitely decreased at once, and the complete subsidence of tenderness requires from three to twelve weeks Extreme corrections on the shoe ($\frac{1}{4}$ to $\frac{1}{3}$ inch elevation of the inside of the heel and outside of the bar) are well tolerated in these cases and usually are preferred since they give more relief than the corrections described for the treatment of pes valgoplanus

The use of these methods results in relief in practically every case, and operation is rarely necessary

In a similar way the supination and pronation brought about by a properly built, form-fitting arch support will act to relieve the strain and decrease the symptoms and a sponge rubber or felt ring cut out to encircle the tender area may give some relief by removing pressure over the irritated point.

A sharp projection in a plantar direction however had best be removed. This is better than trying to relieve the pressure points by encircling with a rubber sponge or felt ring It is conceivable that the inflammation may be of such long standing and the changes so great as to resist ordinary conservative treatment In such cases removal of the projection through a lateral incision may be inadequate, and there may be a recurrence of the exostosis For this reason it has been suggested that the heel be encircled with a horseshoe incision and the rough abnormal surface of the calcaneus be removed in its entirety by means of a wide osteotome The altered periosteum and the chronically inflamed bursa are removed

PERIOSTITIS OF THE CALCANEUS

The calcaneal spur has been explained on a basis of an inflammatory reaction, and its association with inflammation of the periosteum has been demonstrated The periosteum of the calcaneus may, however be inflamed without giving rise to an exostosis or spur Periostitis may be the result of repeated trauma, but most frequently is related to an infectious process It may be the result of a specific infection such as tuberculosis, syphilis or gonorrhea or the infection may be nonspecific as in chronic infectious arthritis

Periostitis as the Result of Trauma Periostitis of the calcaneus may occur as the result of severe trauma to the heel It may be associated with a fracture of the calcaneus The periosteal inflammation sometimes persists for months after the fracture has united As a result of traumatic periostitis, the calcaneus is painful and tender In long-standing cases the periosteum is thickened, as seen in the roentgenogram Repeated slight trauma or chronic strain will also cause traumatic periostitis Inflammation of the periosteum occurs when the short plantar muscles or the plantar aponeurosis is strained The periosteum on the anterior plantar surface of the calcaneus is painful and tender

Treatment. Treatment for traumatic periostitis of the calcaneus consists in rest, elevation of the foot and the application of moist heat After a severe injury the calcaneus is protected when weight bearing is started, and air-blown sponge rubber is used in the heel of the shoe until the tenderness has subsided entirely When the periostitis is due to strain on the plantar aponeurosis and short plantar muscles correction of the foot strain will give relief (See Treatment of Foot Strain under Pes Valgoplanus)

Periostitis Related to Infections. Tuberculosis of the periosteum is relatively rare and is usually associated with tuberculosis in the talocalcaneal articulation

Periostitis of the calcaneus due to syphilis shows smooth thickening of the periosteal membrane in the roentgenogram It is usually associated with a positive complement fixation test The treatment consists in antisyphilitic measures

Chronic periostitis of the calcaneus as a result of gonorrheal infection is usually associated with involvement of other structures in the region of the heel.

SPECIFIC INFECTIONS OF THE CALCANEUS

Gonorrhea Of the specific infectious diseases the most frequent to involve the heel is gonorrhea It may affect the ankle joint or it

may be periarticular and involve the tendon sheath and subcutaneous tissue. The area concerned usually becomes extremely painful, red and swollen Local heat is present. In some cases the tendon sheaths are involved in the infection

The ankle joint and the joints in the tarsal area are most frequently affected The bursae may become involved and will be the last to subside. The bursa beneath the calcaneus becomes chronically inflamed This bursitis occurs so constantly that for many years all calcaneal spurs were believed to be gonorrheal in origin The bursa between the calcaneus and tendo achillis may be involved and will give pain in this region In chronic cases the posterior part of the calcaneus in the region of the bursa is involved in the infection The bone softens and forms small cystic areas in the dorsal part of the tuber calcanei

Treatment When the heel is involved in a gonorrheal infection the infection is treated first. During the acute stage the heel is kept at rest the foot and ankle are kept quiet with a sheet wadding compression bandage With subsidence of the acute inflammation heat is applied with the foot elevated.

Penicillin has supplanted fever therapy as a means of treatment for gonorrhea. This applies for the chronic as well as the acute cases Daily doses of 300 000 to 600 000 units parenterally for two to four days, have been found effective The benefit is not only in the treatment of the general infection but also in the relief of symptoms in the area of the heel

A plaster of paris cast may be necessary to permit weight bearing The cast is removed in two to six weeks, when a Gibney bandage may be applied In some cases where the foot remains extremely weak, a form fitting arch support may be utilized temporarily Ultimately the foot is restored to normal function with the corrective shoe, as used for the treatment of pes valgoplanus.

Periostitis Due to Chronic Infectious Arthritis. There is a generalized picture of a low grade infection in these cases There is a slight rise in temperature, a lowering of the level of hemoglobin and from time to time, a leukocytosis The sedimentation rate is altered The condition is usually due to a focal infection paranasal sinuses, the teeth tonsils or prostate gland most frequently being the primary focus

Periostitis of the calcaneus due to chronic infectious arthritis gives rise to a roughening of the entire periosteum and to exostoses The roughening and calcaneal spurs may be on the dorsal or plantar

surface of the calcaneus The heel is painful and the calcaneus is tender to pressure

Treatment General treatment of the chronic infectious arthritis is essential In addition rest and heat, either hot packs or diathermy, are of benefit. Protection of the heel by means of sponge rubber offers some relief The patient is taught to walk with normal gait in order to avoid trauma to the painful heel. Occasionally, plantar projections and large spurs give rise to pain, and it may be necessary to remove them by surgery

BURSITIS IN THE REGION OF THE CALCANEUS

The bursa and tendon sheaths in the region of the foot are frequently involved in cases of chronic infectious arthritis At the same



Fig. 83 Bursitis with callus formation in the region of the calcaneus

time there is arthritic involvement of the articulations of the foot. The tendon sheath just posterior to the calcaneus becomes inflamed There is an enlargement at the insertion of the tendo achillis and this area is painful and tender (Fig. 83) The bursa between the calcaneus and tendo achillis may become so chronically involved that the inflammatory thickening persists and there may be an overgrowth of the calcaneus in this area

In such cases it is advisable to remove the bursa and the irritative projection of the calcaneus in that area This is carried out through a small lateral incision immediately anterior to the tendo achillis The bursa which has the appearance of an inflammatory mass, is dissected free and removed With a chisel or osteotome the exostoses are removed at their bases to leave a smooth surface on the calcaneus The fat pad between the tendo achillis and the calcaneus

may be thickened and chronically inflamed, if so it too is excised. In every case in which operation is performed it must be remembered that the condition is part of a general disease and that the operative procedure must be *supplemented by treatment directed against the* arthritis

TRAUMATIC ACHILLES TENDINITIS

Traumatic achilles tendinitis is an inflammation around the tendo achillis where it inserts into the calcaneus Technically it is not a tendonitis but the tissue surrounding the tendon is inflamed. The tendon *sheath* in this region does not form a true sac, but there is a covering of the tendon which becomes inflamed as the result of chronic irritation The tendon with its covering is surrounded by *adipose tissue held together by fibrous tissue. This protective tissue* also becomes inflamed. The mechanical irritation that sets up these inflammatory reactions is the result of strain If the tendo achillis is *kept under tension over a prolonged period, the area of its inser*tion and the surrounding structures become irritated In the same way a sudden force, such as may occur in athletics is likely to set up an irritation

The posterior surface of the heel becomes tender and the pressure of the shoe tends to aggravate the condition It is frequently necessary to cut the counter of the shoe Use of the posterior group of muscles increases the pain There is a tendency to walk with a flat footed gait with the foot externally rotated. The condition will subside temporarily after rest only to recur on use.

Treatment. The posterior group of leg muscles should be relaxed and held at rest This is accomplished with a Gibney bandage, which fixes the foot in slight plantarflexion The heel may be raised by means of a felt or sponge rubber pad in the *shoe Fixation must be* carried out until all the inflammation has subsided, which takes a period of at least three weeks In the early stages heat and massage *will increase the symptoms* After the fixation has been removed, however the use of hot packs followed by massage is indicated This treatment is continued until the foot can be brought into normal dorsiflexion without pain

APOPHYSITIS OF THE CALCANEUS

(Haglund's Disease)

Apophysitis of the calcaneus is an inflammation on its posterior aspect with involvement of the epiphysis The epiphysis ossifies in girls at about seven and in boys at about ten to twelve years of age.

It may arise from a single center, or there may be multiple centers of ossification These centers gradually unite to form a semilunar shaped bone which later becomes fused to the calcaneus proper

There is some variation in the time when this fusion of the epiphysis with the bone takes place. It usually occurs at the age of about fifteen to eighteen years, so that after this period no car tilaginous disk is visible between the epiphysis and the calcaneus The most rapid changes in the epiphysis occur between the ages of ten and twelve years and the painful condition of apophysitis is most frequently seen during this period

The disturbance may be unilateral or bilateral Curiously the changes seen roentgenographically may be greater in the foot that is symptom free than in the foot that is giving rise to the symptoms The condition is similar to epiphyseal disturbances in other regions of the body It may be considered a disturbance in the development of the epiphysis similar to that of Legge-Perthes' disease of the hip or to the Osgood Schlatter disease of the anterior tuberosity of the tibia

Etiology The cause of this disease is not established It is not certain that true inflammation is present, since there has been no occasion for surgical intervention in the condition. It is usually seen in children between the ages of ten and twelve years, rapid growth is believed to be a factor In most cases there is an associated pes valgoplanus The valgus at the heel is appreciable. The fact that correction of the valgus will in most cases give immediate relief of the symptoms shows that valgus is a factor in the causation Irrita tion of the epiphysis during this period will give rise to an increase in symptoms This irritation may result from increased tension on the tendo achillis Relaxation of the tendo achillis by means of a high-heeled shoe will frequently result in subsidence of the pain

Any injury or condition that will increase muscle spasm in the posterior group will cause further irritation at the epiphysis At the same time tension on the plantar aponeurosis which attaches to the calcaneus has a tendency to set up irritation in the region of the epiphysis When there is tension on the plantar aponeurosis and on the tendo achillis simultaneously there will be a tendency for sepa ration and consequently greater irritation of the epiphysis

Since foot strain and pes valgoplanus bring about tension on the plantar aponeurosis and tendo achillis they may be considered the most frequent causes of irritation in the region of the calcaneal epiphysis Pes valgoplanus or foot strain between the ages of ten and twelve years can therefore be considered the most likely cause

of apophysitis Friction rub from a stiff counter in the heel of the shoe may be an additional factor

Symptoms. The chief symptom is pain in the region of the posterior process of the calcaneus it occurs between the ages of seven and eighteen years most frequently between ten and twelve. There is a definite tenderness to pressure over the posterior aspect of the calcaneus at the margin where the epiphysis joins the calcaneus. Sometimes the symptoms may be ascribed to a direct blow or injury to the heel Usually there is an insidious onset. There may be a slight swelling over the posterior surface of the calcaneus



Fig 84 Roentgenogram of apophysitis of the calcaneus

The roentgenogram shows the characteristic changes (Fig 84) Depending on the age, there will be more or less fusion of the epiphysis to the calcaneus The epiphyseal line is usually roughened. Both feet are generally involved The epiphysis may show multiple ossification centers which have not fused not infrequently there are two (bipartite) or three (tripartite) centers of ossification The epiphyseal line is cloudy and abnormally irregular The calcaneus in the region of the epiphysis will show some irregularity in condensation The epiphysis may be flattened and fragmented There is a variation in the condensation which gives it a moth-eaten appearance

Treatment Treatment consists in relieving the tension on the

epiphysis In the acute phase it may be necessary to obtain rest by means of fixation with a plaster of paris cast. The cast is applied with the foot in slight plantarflexion The opposite shoe may be elevated and crutches worn or a walking caliper can be applied directly to the cast and weight bearing resumed. Usually the raising of the heel of the shoe with removal of the counter will give relief When pes valgoplanus is present correction of the valgus at the heel frequently results in immediate relief of symptoms, in other cases it may be necessary to wear the corrective shoe for three to twelve weeks before relief is obtained

This is a self-limiting disease that always ends with fusion of the epiphysis to the calcaneus this occurs between the fifteenth and eighteenth years Healing sometimes occurs with an overgrowth or enlargement of the epiphysis This leads to a projection that sets up an irritation of the bursa between the calcaneus and tendo achillis in which case it may be necessary to remove the bursa and the overgrowth of bone to obtain permanent relief

Cases have been reported in which trauma to the epiphysis and an open wound which had become infected resulted in true epiphysitis. This may be a low grade infection which gradually subsides leaving no serious after-effect, or it may be a suppurative epiphysitis in which there is some loss of structure The end result in these cases, however gave rise to no permanent disability

BURSITIS IN THE REGION OF THE TENDO ACHILLIS

In this condition the achilles bursa becomes inflamed Characteristic of the condition is a projection of the heel in the region of the insertion of the tendo achillis

Etiology The bursa becomes inflamed because of a friction rub set up between the tendon posteriorly and a projection on the dorsum of the calcaneus anteriorly This projection may be a true exostosis or as Haglund has pointed out it may be due to an increased angulation of the upper posterior corner of the calcaneus

Symptoms The condition gives rise to repeated attacks of pain in the region of the posterior surface of the heel The patient is unable to wear a normal shoe, and in order to walk, a high heel is necessary If the trouble is allowed to continue over a period of years, the tendo achillis becomes shortened to the point where the heel does not touch the ground in walking barefoot. Dorsiflexion is limited, and an attempt to force the foot dorsally causes pain in the region of the heel The prominence is evident, not only posteriorly but also on the lateral side of the tendo achillis The roent

genogram reveals the existence of a projection and a comparison of the heels will give evidence of the increased angle at the dorsal posterior margin

Treatment Symptomatic relief is obtained, as already indicated by the use of high heels The counter of the shoe may be cut. In some cases relief is secured by the application of felt pads on the medial

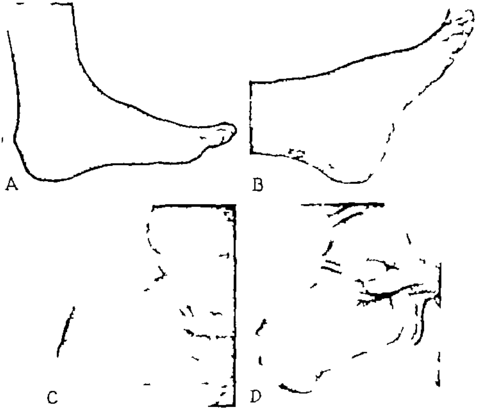


Fig 85 Bursitis in the region of the tendo achillis *A*, Note the prominence in back of the heel, *B* the foot after operation *C* roentgenogram before operation, showing prominent dorsal posterior margin of the calcaneus *D* roentgenogram after operation

and lateral sides of the heel These can be fastened to the counter of the shoe To avoid pressure from the upper margin an inner raise may be placed in the heel.

The curative treatment is operative (Fig 85) A lateral longitudinal incision is made immediately anterior to the tendo achillis running proximally from the upper margin of the calcaneus for 1¼ inches The fatty tissue between the calcaneus and tendo achillis is then removed The bursa is identified and if thickened and inflamed is also excised Since the tendo achillis inserts on the posterior

surface of the calcaneus lower than the plateau of the upper margin of this bone, the upper border of the bone is easily exposed. A much greater projection of bone will be found than was indicated roentgenographically. The projection can be seen to press against the tendo achillis. With a flat chisel, it is easily removed. Periosteal elevators are used to protect the soft tissues. The medial margin is removed carefully. The lateral margin is readily approached and can be beveled to give a smooth surface.

The wound is then closed and the foot kept at rest for a period of ten days to two weeks. A plaster of paris cast may be applied with the foot in slight plantarflexion, or a compression bandage of sheet wadding and gauze bandage may be adequate.

REFERENCES

Brandes, M. Zur operativen Behandlung des Calcaneusspornes. Zentralbl. f. Chir. 54:1602, 1927.

Chang, C. C., and Miltner, L. J. Periostitis of the Os Calcis. J. Bone & Joint Surg., 16:355, 1934.

Haglund, P. Ueber Fractur des Epiphysenkerns des Calcaneus, nebst allgemeinen Bemerkungen ueber einige aehnliche juvenile Knochenkernverletzungen. Arch. f. klin. Chir., 82:922, 1907.

Lewin, P. Apophysitis of the Os Calcis. Surg., Gynec. & Obst., 41:579, 1925.

6

9

POSTURAL DISTURBANCES AND THE FOOT

Functional decompensation of the foot is due to an increase in the demands made upon it or to a decrease in its strength This holds true for the other weight bearing articulations namely the ankle, the knee, the hip, and the sacroiliac and lumbosacral joints Consequently static disturbances in these structures are closely related

Functional decompensation of the foot as we have seen results in pes valgoplanus Valgus of the heel occurs primarily at the talocalcaneal articulation which is therefore subjected to mechanical strain *Irritation and arthritis of the talocalcaneal articulation* cause pain and loss of motion and make walking difficult A static deformity may also occur at the talocrural articulation as the result of a malunited fracture Severe sprains which do not receive adequate treatment may result in elongated medial or lateral ligaments that permit lateral motion at the ankle joint Static strain at the ankle joint may also occur secondary to genu varum or genu valgum These static strains cause irritation of the ankle joint Inflammation occurs in the articulation causing pain and limitation of motion In long-standing cases arthritic changes will be apparent in the roentgenogram

With the heel in valgus as we see it in pes valgoplanus weight bearing through the lower extremity is brought medial to its normal line, with the result that there is an increased strain upon the knee. If this medial strain is continued in a child the knee is also brought into a valgus position and there is genu valgum (Fig 86) When the genu valgum is primary there is a tendency toward valgus at the heel and pes valgoplanus On account of this relationship between pes valgoplanus and genu valgum correction of the position of the heel will exert a beneficial influence on the deformity at the knee In other words in the child with genu valgum and pes valgoplanus correction of the pes valgoplanus will provide a corrective

force against the genu valgum This is borne out by practical experience; the genu valgum of childhood has been corrected simply by correction of the pes valgoplanus

The presence of genu varum will influence the position of the foot With a varus deformity of the lower extremity, in order to place the heel flat on the surface of the floor it is necessary to bring the ankle into slight valgus This compensatory valgus of the ankle is encountered in rachitic genu varum In this rachitic type there is sometimes an internal rotation of the tibia which expresses itself

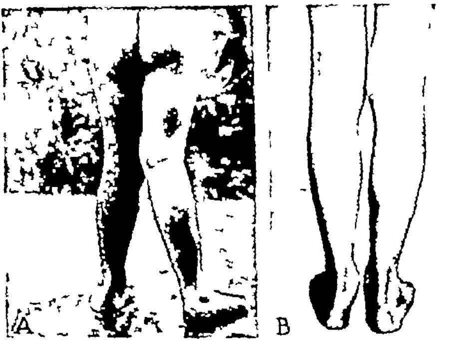


Fig 86 Static pes valgoplanus with genu valgum A. Before treatment B During treatment.

in an inversion and adduction deformity of the foot The reverse may also occur If the inversion and adduction deformity is allowed to persist it may ultimately bring about a torsion of the tibia.

Functional decompensation in the hip may be an influential factor in bringing about coxa vara or an epiphyseal disturbance at the head of the femur In adult life it will tend to cause arthritis deformans of the hip

In standing the sacroiliac and lumbosacral articulations receive proportionately less strain than does the foot The strain on these articulations is more constant inasmuch as they continue to carry a load even while sitting. Functional decompensation of the back will cause strain at the lumbosacral and sacroiliac articulations It

will cause an increase in the normal lumbar lordosis and a rounded dorsal kyphosis. This in turn will result in an increased angulation at the lumbosacral angle, with more strain at this articulation particularly on the ligaments Constant strain in this area will set up an inflammatory reaction which is a frequent cause of low-back pain.

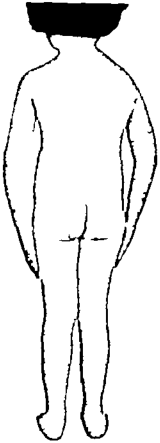


Fig 87 Static pes valgoplanus associated with genu valgum and poor posture

In a similar way a strain will affect the sacroiliac articulation Since this is also a common cause of low back pain an understanding of the condition and its relationship to other static deformities particularly those of the foot cannot be overemphasized If one foot receives more weight than the other the imbalance will be continued to the sacroiliac articulation one articulation will receive more weight than the other When one sacroiliac articulation is inflamed, the body weight will automatically be shifted to the opposite one, in an attempt to protect the inflamed joint Thus the foot on the side of the normal sacroiliac articulation will receive an increased

same static factors with the exception of sitting, hold fo deformities involving the back, knee or foot. In addition to of the causative factors, treatment for low back pain due tional decompensation includes correction of the deform moval of the inflammation at the lumbosacral and sacroiliac lations and reestablishment of normal strength This is plished by a corrective cast the use of form fitting supports rest and functional exercises plus the reestablishment of carriage and correct gait

LOW-BACK PAIN

Weight bearing as it comes through the foot must be giv sideration in the treatment of low back pain The poor which is a symptom of functional decompensation of the practically always associated with static changes in the foot. gait is impossible with poor posture; by the same token poor is impossible with normal gait This means that reestablishn normal gait is important in the correction of functional dec sation of the back.

Impaired posture is usually associated with a flatfooted g use the foot as an organ of propulsion and to walk with a gait, correct posture is essential This correct carriage depe the capacity of the trunk muscles If the muscles are strong to retain an erect position then it is a relatively simple pro to teach a normal heel-and-toe gait With correction of pes planus by my method there is an improvement in posture. fore, the treatment of low-back pain due to functional decom tion includes reeducation to the normal gait

In the treatment of unilateral involvement of the sacroiliac lations emphasis is placed on establishing normal weight-b balance. For example, in case one extremity is shorter tha other this shortening is compensated for by elevation of the In cases of apparent shortening, static strain is decreased by e ing the weight distribution with a raise on the shoe. With c the sacroiliac lesion the apparent shortening disappears and c tion is no longer necessary

The treatment of the arthritis due to static changes is des under Arthritis Deformans of the Foot or Arthrosis

REFERENCE

Hauser, E. D. W. The Treatment of Low Back Pain Due to Func

10

ARTHROSIS

ARTHROSIS OF THE FOOT

As the result of irritation due to repeated trauma, the articulations of the foot are subject to arthritic changes This type of arthritis is entirely on a static basis, and for this reason will be referred to as an "arthrosis" to differentiate it from the arthritis which is on an infectious basis and is referred to as "arthritis deformans" in this text (see p 314) All weight bearing joints are exposed to repeated trauma and are frequently the scene of arthritic change. The older the person the greater the changes This is due not only to the accumulation of wear as the result of prolonged use, but also to a loss of elasticity in the tissues with age With this loss of elasticity and the inability to replace cartilage with new cells, arthritic changes develop When the alignment of the articulations deviates from normal additional strains are applied and the wear is unequal. When constant pressure and rubbing takes place, the cartilage may be worn away until the bone is denuded.

Another source of increased demand on an articulation is an increase in body weight. This is doubly important when the muscles and ligaments have become weaker Injury to a ligament may likewise increase the strain on an articulation sufficiently to cause an arthritic change.

The type of arthritic change varies from a destructive lesion to a hypertrophic lesion In a destructive lesion a fragment of cartilage may become separated to form a loose body or joint mouse. In the same type of case there may be large exostoses—so large that they may be fractured by sudden trauma The possibility of such fractured fragments becoming loose bodies has been suggested Therefore articular changes, which may be either hypertrophic or atrophic, inasmuch as the joint surface is decreased and the cartilage is lost are relatively common occurrences in the articulations of the foot

This arthrosis is a result of traumatic irritation and is frequently seen in all weight-bearing articulations The most classic example of this type of arthrosis is seen in the knee joint but modifications are seen in the ankle joint and in the joints of the foot

ARTHROSIS OF THE ANKLE JOINT

Usually the ankle joint is not altered mechanically as the result of static strain Whenever an alteration in weight bearing occurs for any reason the strain is great and the arthritis is clinically important. For instance, after a malunited fracture at the ankle joint in which the weight bearing no longer comes through in the



Fig 88 Arthrosis at the ankle joint as a result of trauma and repeated inflammatory reactions A, Roentgenogram, lateral view *B* roentgenogram posterior view

proper direction the ankle joint is subjected to a severe strain and irritation occurs If the ankle is in valgus the medial ligaments become inflamed The external half of the trochlea of the talus is subjected to increased pressure and the cartilage may become worn thin in that area Exostoses develop gradually around the margin of the trochlea and the joint surfaces become roughened Motion at the joint is painful The periarticular irritation sets up a reflex muscle spasm and causes limitation of motion

The changes in the joint continue until there is a partial block to joint action These changes may ultimately become so great that all weight bearing particularly with motion causes pain In a simi

lar way, severe sprain in which the ligaments are torn may give rise to an altered position and to partial subluxation With this subluxation and weight bearing, inflammation occurs at the joint. Repeated inflammatory reactions ultimately produce the typical changes of arthrosis (Fig. 88)

Symptoms. The local symptoms of these arthritic changes in the ankle joint are similar to those of an infectious arthritis There is pain swelling, increased fluid increased pain on motion, tenderness over the strained ligaments, and sometimes muscle spasm The roentgenogram shows loss of joint space, a roughened surface and increased sharp margins of the bone with exostoses Occasionally, loose bodies may be seen

Treatment The treatment may be divided into two phases treatment of the inflammation, and removal of the causative factors Treatment of the inflamed joint consists first of all in rest in bed The foot is elevated, and hot moist packs are applied The moist dressings can be kept warm with an infra red lamp or electric baker During the acute attack intense heat should not be used, since it tends to increase pain With the subsidence of the acute symptoms the heat can be increased and light massage added Heavier massage to the muscles of the leg and thigh will keep up their strength When the muscle spasm subsides the foot can be brought into the mid position and held with a plaster of paris cast. A caliper can then be applied to the cast and weight bearing may be started If the arthritic inflammation is relatively mild it may be possible to control it by bringing the foot into normal position and fixing the ankle with a Gibney bandage until the inflammation subsides

The causative factors are established by the history and by physical examination In cases of malunited fracture, normal alignment of weight bearing is reestablished by manipulation if possible, otherwise by supramalleolar osteotomy The position of choice is then held with a plaster of paris cast A walking caliper is applied to the cast to permit reestablishment of weight bearing with the foot in the corrected position

When the malalignment at the ankle joint is due to improperly healed medial or lateral ligaments the ankle is first brought into normal alignment If this position is held for several weeks by means of a walking cast and then by the corrective shoe, the ligament will sometimes readjust itself to normal. Otherwise, it is necessary to construct a new ligament This is best done by turning down a periosteal flap and attaching it over the area of the old ligament. The weight bearing line through the ankle joint can be altered by

changing the position of the heel at the talocalcaneal articulation The improvement in weight-bearing alignment brought about in this way may be sufficient to relieve the static strain at the ankle and thus bring about a recession in the arthritic process When motion is very painful, it may be limited by means of a brace or by raising the heel.

With extremely painful joints it is occasionally advisable to carry out arthrodesis at the ankle.

ARTHROSIS OF THE TALOCALCANEAL ARTICULATION

Arthrosis of the talocalcaneal articulation occurs frequently Irritation results from altered weight bearing due to a varus or valgus



Fig. 89 Arthrosis of the talocalcaneal articulation Symptoms were relieved by corrective shoes

deformity Static deformity of the foot due to functional decompensation results in a valgus position of the heel at the talocalcaneal articulation A fracture of the calcaneus may alter the direction of weight bearing enough to bring about a strain at this articulation (Fig. 89) The fracture may involve the articulation directly Trauma or strain here will then result in inflammation and arthritic changes Loss of joint surface at the talocalcaneal articulation is difficult to demonstrate but marginal overgrowths are readily seen in the roentgenogram

Symptoms There is pain with weight bearing Motion at the talocalcaneal articulation is painful and limited. Muscle spasm may occur in the peroneal and calf muscles

Treatment In the acute phase treatment consists in rest, elevation of the foot and local heat The heel is brought into the position of choice and held with a plaster of paris cast. A walking caliper may then be attached to the cast to permit early resumption of gait The cast is followed by the use of the corrective shoe When the arthritic changes are advanced and correction of the deformity cannot be carried out in this manner arthrodesis of the talocalcaneal articulation is indicated In these cases the talonavicular and calcaneocuboid articulations are also involved and are therefore fused at the same time.

ARTHROSIS OF THE TALONAVICULAR ARTICULATION

The talonavicular articulation is involved in practically every case in which there is arthrosis of the talocalcaneal articulation (Fig 90)



Fig. 90 Arthrosis of the talonavicular articulation Note overgrowth of margin. The condition was a result of chronic foot strain

An arthritis due to static strain will arise in this joint, since the weight from above meets the pressure from the floor below in this region Arthrosis of this articulation is caused by the altered position of the head of the talus in case of pes valgoplanus The head is partially subluxated so that the medial and inferior parts receive less weight bearing than normal whereas the lateral and dorsal parts

are subjected to increased pressure. The margins of this articulation may project upward. The area where the dorsal ligaments are attached is inflamed and a periostitis arises this may be increased as the result of pressure from the shoe.

Symptoms. There is a projection on the dorsum of the foot which may be sensitive to pressure. There may also be tenderness over the medial and plantar surfaces of the articulation Because of pain in the area of the talonavicular articulation it is impossible to bring the anterior part of the foot into pronation with the heel held in varus The roentgenogram reveals exostoses along the dorsal margin

Treatment. The acute inflammation is treated by elevation of the foot and by hot applications The dorsal margin is protected from friction rub by padding the tongue of the shoe; or a doughnut like felt pad may be applied directly to the skin encircling the articulation The essential treatment, however is the removal of the static deformity, accomplished by correction of the pes valgoplanus Cases have been reported in which the condition occurred as the result of raising the arch too high In these cases lowering of the arch support gave relief

It is sometimes necessary to fuse this articulation along with the arthrodesis of the talocalcaneal articulation in order to eliminate the symptoms of the arthrosis

ARTHROSIS OF THE CUNEONAVICULAR ARTICULATION

This articulation is subjected to strains similar to those described for the talonavicular articulation and in many ways the response is the same Exostoses of the dorsal margin may project and cause irritation as the result of pressure from the shoe.

The symptoms and treatment are essentially the same as those for arthrosis of the talonavicular articulation

It is sometimes necessary to remove the dorsal exostosis This is done through a dorsomedial incision The dorsal ligaments are reflected away from the bone sufficiently to allow removal of the exostosis. The ligaments are then carefully sutured back into place. The correction is directed against the static deformity of the foot

ARTHROSIS OF THE CALCANEOCUBOID ARTICULATION

The calcaneocuboid articulation occasionally shows exostoses by roentgenogram and in severe cases of arthrosis it should be included in the fusion operation which is directed against the talocalcaneal and talonavicular articulations

ARTHROSIS OF THE TARSOMETATARSAL ARTICULATION

The arthrosis that occurs in the articulation formed by the cuneiform and the first metatarsal bone is described under exostoses on the dorsum of the foot

ARTHROSIS INVOLVING THE METATARSOPHALANGEAL ARTICULATION OF THE GREAT TOE

Arthrosis of the metatarsophalangeal articulation of the great toe is described under Hallux Rigidus As a result of the arthrosis, a



Fig 91 Arthritis deformans (arthrosis) of the metatarsophalangeal articulation of the great toe, associated with hallux valgus. Irritation of the articulation led to roughness of the joint surface and overgrowth of the margin.

large exostosis may arise on the dorsum of the foot The osteophyte is constantly subjected to friction rub from the shoe. A bursa develops between the skin and the exostosis and becomes chronically inflamed A heavy callus then forms on the skin in this area

Treatment Treatment consists in excision of the callus and removal of the bursa With an osteotome or chisel the exostosis is removed and the bone is made smooth.

Occasionally the exostosis in this area presses against the digital nerve and causes a peripheral neuritis in the great toe. The toe is

painful and paresthesias occur Pressure from the shoe increases this pain (Fig 91) Treatment consists in careful exposure and identification of the nerve The *nerve is retracted* while the exostosis is removed with a chisel

EXOTOSES ON THE DORSUM OF THE FOOT

A common cause of disturbance, particularly in people suffering from static foot troubles is an inflamed area on the dorsum of the foot over the medial longitudinal arch. This inflammation is over the site of a projection of bone which occurs in the region of the *tarsometatarsal articulation* (Fig 92)

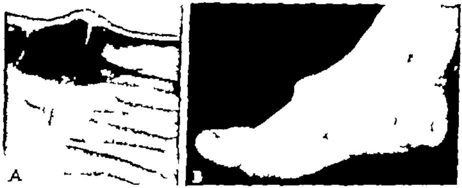


Fig 92 *A*. Roentgenogram of exostosis on dorsum of foot with projection of margins of the tarsometatarsal articulation and soft tissue swelling *B* Photograph of foot

Etiology Static changes cause a projection of the margins at the tarsometatarsal articulation The *force of the body weight* from above and counter pressure of the floor from below meet in the region of the navicular and first cuneiform bones With excessive weight the head of the talus and the navicular are depressed The first cuneiform bone is tilted so that the posterior part is lower than the interior The *anterior margin of the cuneiform bone projects* dorsally Counter pressure from the floor displaces the first metatarsal bone dorsally at its articulation with the first cuneiform

Symptoms. These projections give rise to an elevation that has the appearance of an exostosis The counter pressure from the floor and the *friction rub of the shoe* over this area set up an inflammatory reaction which results in pain swelling and redness This swelling may involve not only the skin and subcutaneous tissue but also the periosteum If the condition persists over a long period

tions give rise to a bony exostosis which is seen as a dorsal promontory

Treatment Since the condition is the result of static disturbances treatment should be directed toward their removal These exostoses are associated with two types of feet, talipes cavus and pes valgoplanus In both instances the ligaments are relaxed and one is dealing with the loose or flaccid type of foot If one sees this condition with a talipes cavus an equinus deformity is usually also present This deformity is generally due to the wearing of high heels, resulting in a shortening of the tendo achillis Correction of the equinus is indicated When the exostosis is not of long standing lowering of the heel of the shoe is usually sufficient to bring about relief from the disorder When the exostosis is seen in connection with a loose type of pes valgoplanus correction of this condition is indicated The treatment described under Pes Valgoplanus will usually give relief

Symptomatic relief is obtained by local treatment, which consists in protection of the irritated area from the shoe This is accomplished by placing a felt pad inside the tongue of the shoe in such a way that no pressure comes over the dorsum of the tarsometatarsal articulation While there is acute inflammation, hot moist dressings are applied.

When the condition is of long standing and the roentgenogram shows excess overgrowth the conservative treatment may not give complete relief in this case operative removal is indicated under local anesthesia A small slightly curved incision is made over the dorsomedial side of the foot The dorsal ligaments are then separated from the bone with a periosteal elevator The exostoses at the joint margin are then removed with a thin osteotome The ligaments are sutured over the dorsum of the articulation and the wound is closed

11

TALIPES

(Clubfoot)

TALIPES EQUINOVARUS

Talipes equinovarus is the unsightly deformity commonly called clubfoot. As the name suggests, there is a plantarflexion deformity with varus the foot being twisted into an inverted and plantar flexed position This means that the heel is in varus and the anterior part of the foot is supinated and adducted. The foot is in equinus position so that on weight bearing, only the ball of the foot comes in contact with the ground When the foot is plantarflexed and inverted simultaneously it is foreshortened The height of the longitudinal arch is raised and a cavus deformity is present Talipes equinovarus or clubfoot is therefore a triple deformity a combination of equinus inversion and cavus (Fig. 93)

The degree of alteration due to each component part is variable in different cases Usually the equinus predominates, sometimes the varus is the most striking feature The supination may be so extreme that the medial side of the foot is directed upward and weight bearing occurs on the lateral and dorsal surfaces of the foot. The intoeing due to the adduction of the forepart of the foot may be exaggerated because of an inward rotation of the tibia This rotation can be measured by drawing a line through the midline of the patella and the midpoint between the medial and lateral malleoli.

Talipes equinovarus may be either congenital or acquired but is most frequently congenital

Congenital Talipes Equinovarus. *Etiology* There are two types of congenital talipes equinovarus one is a simple contracture, and the other is associated with an anomaly The simple type of deformity must be regarded as a postural disturbance The foot is held in an abnormal position in utero Whether or not this is due to a small

intra-uterine space, to interlocking of the feet, to pressure against the uterine wall, or to increased pressure or loss of amniotic fluid is of no great clinical significance. The clinical picture is altered however if an anomaly is present Whether this defect is due to a developmental arrest, an encircling of the foot or limb by the umbilical cord or to an amniotic adhesion will in no way alter the circumstances with regard to the prognosis In some instances there seems to be a nerve defect.

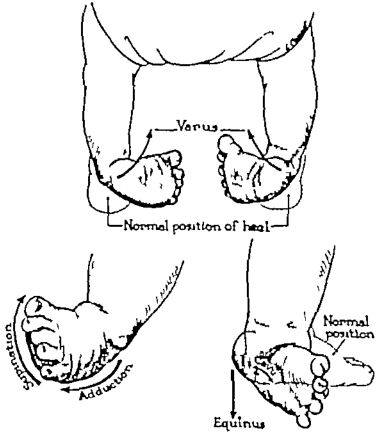


Fig 93 Components of a clubfoot deformity (Hauser in J.A.M.A.)

Interesting to note is the presence of anomalies occurring simultaneously in other parts of the body (Fig 94) The familial tendency of congenital talipes equinovarus has been observed repeatedly This could exist for the pressure type as well as for the anomalous type, inasmuch as a uterine alteration could be conceived of as being hereditary

Symptoms All the structures of the foot are involved *in the* contracture deformity The foot is usually smaller than normal and the heel is underdeveloped In extreme cases the foot may be almost

in a straight line with the leg so that all the weight comes on the ball of the foot or the supination may be so extreme that the patient walks on the dorsum of the foot The foot toes in as a result of the



Fig 94 Deformities associated with talipes equinovarus of the left foot A, Congenital pes valgoplanus of the right foot with anomalies of toes *B* Congenital anomalies of fingers (same patient) (Hauser in J A.M.A.)

adduction of the anterior part and the internal rotation of the tibia and fibula A secondary genu valgum arises The plantar aponeurosis is thickened and shortened thus decreasing the length of the foot increasing the height of the arch and giving rise to a cavus deform

ity. There is a flexion contracture of the toes. The posterior group of muscles is shortened. The contracted tendo achillis displaces the heel dorsally. The supinators, tibialis anterior and tibialis posterior, are contracted, as are also the deltoid and the plantar calcaneonavicular ligaments on the medial aspect of the foot.

The bones adapt themselves to the new position according to Woolf's law, until they show severe deformities. The articular surfaces are altered accordingly. The talus shows the most change as its head deviates inwardly. Congenital talipes equinovarus is essentially a contracture and, like all contractures, increases with growth; the contracted side becomes shorter and firmer and the opposite side becomes longer and weaker.

In infancy the deformity may be relatively slight and not noticeable, but with weight bearing it increases so that it is recognized easily. There is interference with growth in the presence of a contracture deformity. The foot is underdeveloped and there is atrophy of the calf of the leg. The foot is used as a fixed structure rather than as an organ of propulsion and the condition is therefore associated with a limp. Function is relatively good considering the deformity. The painful corns and inflamed bursae over the points of weight bearing cause discomfort and interfere with function.

Prognosis. If the condition is allowed to go untreated, use of the foot makes the deformity worse. With proper treatment of the simple type of congenital talipes equinovarus the foot can be restored to normal. To accomplish this, correction must be begun early and continued until all tendency to recurrence is overcome. This principle must be executed irrespective of the therapeutic methods applied. For the anomalous type, although the procedure is the same and correction may be attained, it is not possible to restore the foot to normal function. Furthermore, it is more difficult to prevent recurrence. Even in a neglected talipes equinovarus of the simple type in an adult the prognosis for correction of the deformity is good inasmuch as the appearance can be improved greatly and a useful foot can be obtained.

Treatment. The earlier treatment is instituted the better, since the tissues are much softer and the contracture is less fixed. Without treatment the deformity increases with growth, which is extremely rapid in early infancy. If correction can be instituted promptly, however, this rapid growth will aid the corrective forces.

The need for correction as early as possible is accepted by all, but owing to the mechanical difficulties of dealing with a nursing child and with so small a structure, there is a difference of opinion

among physicians as to the exact time to begin treatment. It is essential that the therapy be carried out through the first year or at least until the child can walk. Constant observation of a child over so long a period may offer difficulties such as great distance and economic problems. When possible, however, treatment should be instituted early and followed through. Delay is permissible only when necessity demands it.

Before starting treatment it is necessary to obtain the full cooperation of the parents. The need for carrying out continuous treatment until full correction is obtained and the fact that this is not accomplished until the tendency toward recurrence is overcome, must be explained to them.

Treatment can be begun as early as the first day after birth. When the obstetrician calls me in consultation with regard to a congenital talipes equinovarus immediately after birth, I institute treatment at once, particularly if the delivery took place in a hospital that is accessible. For the treatment of clubfoot in the newborn infant and for the period until the child walks, all other methods have been supplanted by the cohesive bandage technic, in my practice.

This cohesive bandage technic consists first in cleansing the foot and leg for at least two minutes with 1:4000 aqueous solution of zephiran chloride* which has the advantage of cleansing the skin and reducing the bacterial count to a minimum without irritation. After the skin is dry, the foot and leg are painted with compound tincture of benzoin with a sterile applicator. When the tincture of benzoin has dried, the cohesive bandage is applied (Fig. 95). The bandage is applied flat, with no wrinkles, and is held at its full width while being wrapped.

Anchoring bands are obtained by encircling the leg just above the bulge of the gastrocnemius muscle (Fig. 95, 1). These bands are necessary since the cohesive bandage will stick to itself but not to the skin. The second anchoring band is applied in the same manner as the first, overlapping the first by half. This is done by the physician with an assisting nurse holding the leg and cutting the bandage.

To correct the varus deformity of the heel, the cohesive bandage is now started from the encircling anchor bands on the medial side of the leg. The physician brings the anterior part of the foot into abduction, pronation and dorsiflexion, thus forcing the heel into the maximum amount of valgus position that can be obtained. Then the bandage is brought along the medial side of the leg, ankle and

* Manufactured by Winthrop Stearns, Inc.

foot, around under the heel and up the lateral side of the leg to be attached to the encircling bands This stirrup type of bandage is repeated overlapping the previous strip by half, and the heel always brought into the valgus position (Fig 95 2) Then an encircling bandage is again applied overlapping by half down to the ankle (Fig 95, 3)

The forepart of the foot is corrected next, it is encircled twice for an anchor bandage overlapping by half The cohesive bandage is

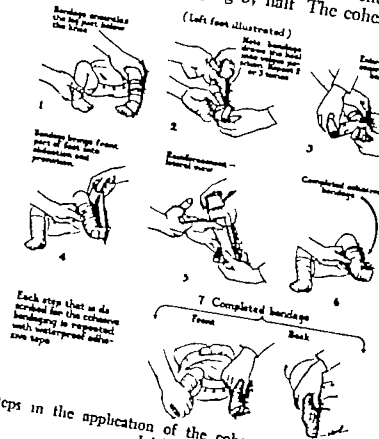


Fig. 95 Steps in the application of the cohesive bandage (Hauser in J.A.M.A.)

then started from the anchor on the dorsomedial aspect of the foot. The foot is brought into abduction and pronation the bandage is carried under it and then obliquely across the dorsum to be attached to the medial side of the leg above the ankle (Fig. 95 4) A second strip is applied overlapping the first by half (Fig. 95 5) These are reinforced until sufficient strength is obtained to hold the corrected position Special care is necessary to obtain a flat bandage over the anterior part of the ankle, since the skin in this area becomes redundant with the correction and there is a tendency to creasing The entire foot and leg are covered with the bandage. The dorsal

and plantar surfaces of the toes are included so that only the very tips are visible. The entire bandage is then molded so that everything is smooth and the foot and leg are thus in a soft smooth, well fitted encasement (Fig 95 6)

In order to obtain a support that is adequate to hold the foot against the constantly contracting muscles it is necessary to have a much stronger bandage. This is accomplished by reinforcement with 2 inch waterproof adhesive tape. The entire technic as described for the cohesive bandage is now repeated with the adhesive tape, the foot again being brought more into valgus position with further abduction and pronation as the tape is applied The entire foot and leg are encircled with sufficient layers of the adhesive tape to counteract the tendency for the foot to resume its original position (Fig. 95 7) These cohesive and adhesive bandages are manually molded so that there is smooth and even pressure throughout the entire extremity

The interval between changes of bandage is variable, depending on the age at which the correction is started and on the severity of the deformity as well as the distance from which the patient is brought *Usually the newborn infant with clubfoot is seen at the* hospital a day or so after birth and treatment is started at once. The technic for a newborn infant is the same as previously described, *with the advantage that since the child can easily be seen each* day at the hospital, the bandage is reinforced daily with more correction in each treatment This is continued for a week. Correction is so rapid at this stage that the bandage becomes ill fitting and an entirely new encasement is applied at the end of a week. This is again reinforced daily and a new bandage is applied the day the mother takes the baby home The child is then brought to the office *two weeks later when the bandage is again renewed. The treatment* is followed through at the office at intervals of two to three weeks because of the rapid change of the foot and the loosening of the bandage so that it becomes less effective

Not only must the deformity be corrected but any tendency to recurrence must be prevented hence the correction is always retained *until the child walks Since the deformity is corrected rapidly* in the early stage, it is sometimes difficult to make the parents understand the need for continuous retention of the foot in the over*corrected position until* walking has established muscle balance For this reason it is important to explain the plan of treatment to the parents at the time it is started At no time is the correction hurried

but once it is started the treatment is continuous Even in case of illness this treatment can be carried out.

It is believed that the internal rotation of the tibia is associated with the adduction of the foot The early correction of the foot will influence the tibial deformity

In some cases a tight tendo achillis will not allow full correction of the equinus deformity Before the child walks and when all other corrections are obtained a subcutaneous tendon lengthening is done. When the child starts to walk, the outer sides of the heel and sole are raised A brace is used to hold the foot in abduction and external rotation (Fig 96)

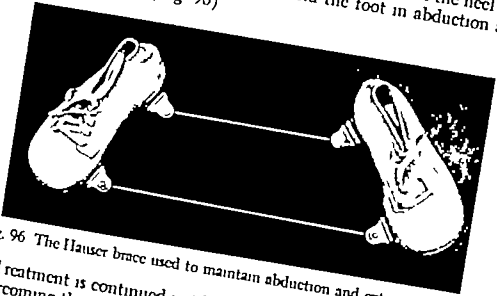


Fig. 96 The Hauser brace used to maintain abduction and external rotation.

Treatment is continued until muscle balance is established thus overcoming the tendency to recurrence (Fig 97)

It is possible to correct talipes equinovarus in all cases irrespective of age, and the feet of all children should be corrected The older the patient however the more the decision should be left to him whether or not he wishes to obtain correction

When the child is brought for treatment after it has been walking, or is more than two years of age the same principles of treatment just described will apply The actual technic will vary however inasmuch as the contractures are firmer and the deformity is more severe

The triple deformity may be corrected gradually by means of manipulation and repeated changes of cast with or without anesthesia Another method is to apply a plaster of paris cast and then remove a wedge from it increase the correction and refasten it with a plaster bandage

In older children I have found it practical to correct the deformity by *means of manipulation and a cast* (Fig 98) *It is frequently best* to do this in two stages under deep anesthesia as described under Manipulation with the Haglund Footboard page 391

Retention of the correction until the inherent tendency toward recurrence has *been overcome* (Fig 99) *requires exacting care* over a long period. The tendency for recurrence is variable. Since the imbalance between the muscles is a factor the overcorrection must be retained until normal balance has been reestablished Any

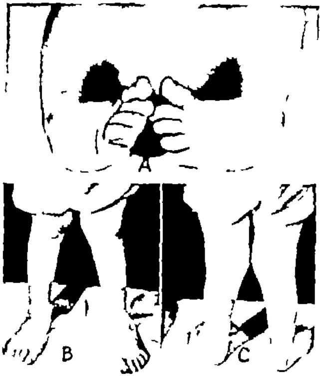


Fig 97 Results of treatment with cohesive bandage A. Severe bilateral clubfoot in a patient aged *2 months B and C. Appearance of the feet after* treatment (age 2 years and 4 months) (Hauser in J.A.M.A.)

residue of deformity will increase with rapid growth the foot must therefore remain under supervision until the child is through the adolescent period since recurrences are likely during these years

After treatment consists in use of the foot with retention of the overcorrected position Walking can be begun as soon as the foot is fully corrected Weight bearing is started on the plaster of paris cast Fastening a heel to the rigid cast is an aid in walking After removal of the cast the type of fixation used depends upon the expected tendency toward recurrence Since this varies in different

cases, surgical judgment is necessary For the anomalous type the Hauser brace for abduction and external rotation is used (Fig. 96)

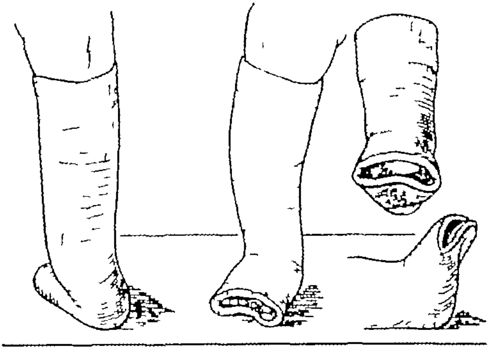


Fig. 98 Satisfactory cast for correction of talipes equinovarus The cast is well molded at the malleoli with a concavity under the transverse arch. The foot is held in abduction and pronation

The greatest difficulty in the correction of talipes equinovarus, as well as in retention of the correction is to overcome the varus

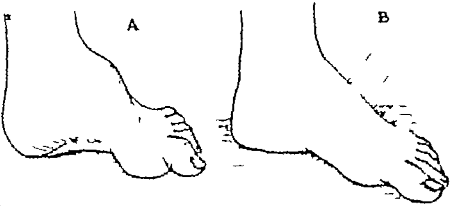


Fig. 99 Sketch of congenital clubfoot in a boy 13 years of age. A, Before correction, B after manipulative correction with Haglund footboard and cast.

at the heel In simple cases the valgus of the heel and abduction of the foot may be held by the corrective shoe alone on which

the outer sides of the heel and toe are raised The shoe is used during the day To retain the position while at rest form fitting splints made of plaster of paris which hold the overcorrection are used *External rotation can be retained by means of these splints* With the feet externally rotated the heels are fastened together by means of a bar

This after-treatment is discontinued gradually as the foot is used more and more in the overcorrected position The foot is observed *periodically and any tendency toward recurrence is counteracted* immediately Slight deformities should be corrected as soon as recognized since as has been said there is a tendency for the de

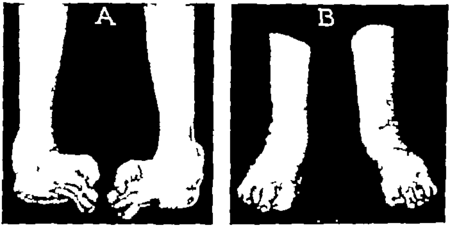


Fig. 100 Bilateral neglected congenital clubfoot in an adult *A*, Before correction *B* after correction by manipulation with the Haglund footboard and Thomas wrench under anesthesia (J.A.M.A.)

formity to increase with the growth of the child Much depends on the cooperation of the parents Interference or neglect of treatment may result in recurrence of the deformity In some cases the condi *tion will recur in spite of every effort*

Recalcitrant and Neglected Talipes Equinovarus. As was seen in the explanation of causative factors there is a type of talipes equinovarus with definite anomalies which offer obstacles to the establishment of a normal foot There are also cases in which recurrences due to incomplete treatment increase the difficulty in correction particularly if such treatment consisted in surgical intervention or forceful manipulation The reasons for this are that the contractures are more severe scarring has been added *in some cases displacement* of a joint has been brought about or the equinus has been corrected before the correction of the supination and varus In these cases

as well as in the entirely neglected talipes equinovarus in the adult the principles of correction are the same as for talipes equinovarus in older children but the technical difficulties are increased. In most cases the technic as described is adequate to obtain full correction and good function (Figs 100 and 101)

When the contractures are extreme or the injury to the articulations has been great, surgical intervention has sometimes been recommended A wedge may be removed the talus may be enucleated,

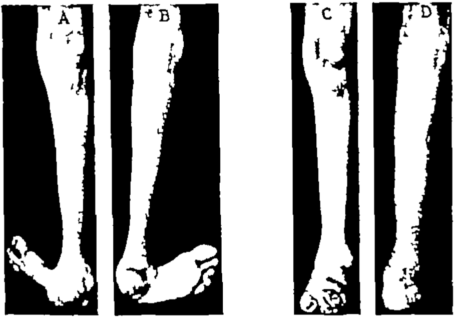


Fig 101 Unilateral neglected congenital clubfoot in a man A, The deformity anterior aspect B the deformity posterior aspect C the foot after correction of the deformity by multiple manipulations with Haglund footboard and Thomas wrench under general anesthesia, anterior aspect; D corrected foot posterior aspect (J.A.M.A.)

or through an open wound the fascia and all the ligaments may be separated from their attachments When the articulations are so severely injured as to be painful on weight bearing, it may be best to perform arthrodesis of the involved articulations after the foot has first been corrected as much as practical by means of the procedures described previously

Summary Summarizing we note that the results of treatment depend on the type of congenital talipes equinovarus involved. In the presence of an anomaly the establishment of an absolutely normal foot is almost precluded but the correction though difficult usually results in a foot of good appearance and good function

the outer sides of the heel and toe are raised The shoe is used during the day To retain the position while at rest form fitting splints made of plaster of paris which hold the overcorrection are used External rotation can be retained by means of these splints With the feet externally rotated the heels are fastened together by means of a bar

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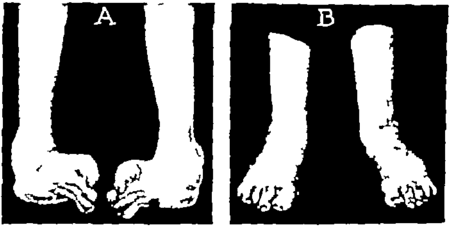


Fig 100 Bilateral neglected congenital clubfoot in an adult A, Before correction, B after correction by manipulation with the Haglund footboard and Thomas wrench under anesthesia. (J.A.M.A.)

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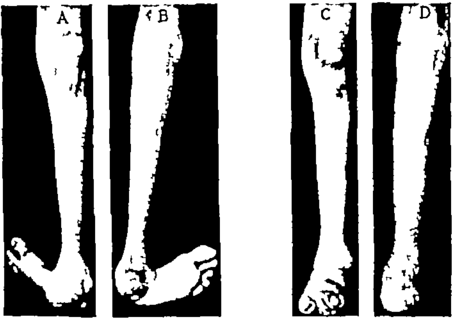


Fig. 101 Unilateral neglected congenital clubfoot in a man A, The deformity anterior aspect, B the deformity posterior aspect C the foot after correction of the deformity by multiple manipulations with Haglund footboard and Thomas wrench under general anesthesia, anterior aspect, D corrected foot, posterior aspect (J.A.M.A)

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in the plantar part of the foot are hypertrophied and contracted. The patient has relatively little interference in walking, the chief trouble being a shortening of the foot, which requires a special shoe, usually one which has to be made to order. The toes gradually become contracted. Calluses form on the ball of the foot and may become very painful. The dorsa of the contracted toes may rub against the shoe and cause painful calluses.

Treatment. The condition is frequently not recognized until the child has been walking for some time. When first observed, the deformity is usually so slight that there is apparently no need for correction, but if it is left untreated and is then observed over a period of years, it can be seen to grow progressively worse.

In the early stages the condition should be combated by manipulation and stretching. The plantar aponeurosis is stretched by forcing the heel backward and bringing the anterior part of the foot into dorsiflexion. With one hand holding the heel in valgus, the other hand brings the anterior part of the foot into supination. The technic for this manipulation can be taught to the parents, who can then carry it out at home. Further correction is secured through the corrective shoe. The heel of the shoe is raised $\frac{1}{8}$ to $\frac{1}{4}$ inch on the outer side, depending on the age of the child and the amount of valgus present. If the pronation deformity is severe, the sole of the shoe should be raised on the inner side. More important is the stretching of the plantar aponeurosis and the short plantar muscles. This is accomplished by a transverse bar on the shoe. This bar lies immediately behind the heads of the metatarsal bones and may be raised slightly on the inner side to form an inclined plane directed laterally. If the condition is recognized early and if the corrections are worn on the shoes for a period of years, the deformity gradually recedes and further development of serious trouble is prevented.

In postadolescence, when the deformity has become more pronounced and has given rise to such symptoms as painful calluses in the anterior part of the foot and to appreciable shortening, manipulative correction under anesthesia is required. This is preceded by subcutaneous fasciotomy and tenotomy. Manipulation consists in forcing the foot against the Haglund footboard with a Spanish windlass, the technic being the same as that in connection with recalcitrant and neglected *talipes equinovarus*. A Scarpa shoe and Lorenz type of manipulative osteotome have also been used. Further to correct the contracted great toe and the plantarflexion of the foot, the extensor hallucis tendon is divided through a dorsal incision at the

level of the head of the first metatarsal bone The proximal end of the tendon is passed through a hole drilled in the head of the first metatarsal bone and fastened upon itself This allows the great toe to straighten and the power to dorsiflex the anterior part of the foot is increased at the same time there is a tendency for supination of the anterior part of the foot. The transplant of the extensor hallucis acts to prevent a recurrence of the cavus deformity The deformity is in the first metatarsal bone so that the transplant is usually limited to the extensor hallucis longus Some surgeons however have found it necessary to perform a similar operation in connection with the other toes Usually adequate correction of these toes is obtained by means of the corrective shoe

In this type of deformity lengthening of the tendo achillis is unnecessary and detrimental and should therefore be avoided

Talipes Cavus Secondary to Spina Bifida. This condition is on a neurogenic basis and the deformity is associated with atrophy and reflex changes Spina bifida is congenital and the trouble in the foot may scarcely be apparent at first. In many cases the condition is not recognized in early childhood It grows progressively worse, however until about the adolescent period when there is a noticeable deformity The severity varies with the neurogenic changes and these in turn depend upon the severity of the spina bifida There are contractures and interference with gait, and not infrequently the disorder is complicated by trophic ulcers

Treatment Correction of this deformity must be executed with particular caution, inasmuch as the circulation is impaired and there is a tendency toward trophic lesions Conservative treatment is most valuable It consists in gentle manipulation followed by casts The casts are changed repeatedly at intervals of several weeks Gradually more correction is obtained until the foot can be brought into the midposition where it is retained At first casts and later braces are used for retention. After correction of the deformity gait is taught with the use of the retention casts and brace or sometimes a walker

Talipes Calcaneus. The acquired type of talipes calcaneus is usually due to paralysis of the posterior group of muscles of the leg It may be complicated by loss of function in other muscles This type of arcuatus is characterized by a change in position of the calcaneus With loss of the posterior group of muscles and an active force in the short muscles of the plantar area the calcaneus is drawn forward The tuberosity of the calcaneus may be directed vertically rather than horizontally Since in the majority of cases

the condition is due to infantile paralysis it is also considered under Deformities of the Foot Due to Anterior Poliomyelitis.

Treatment Treatment depends on the severity of the paralysis and also to some extent on the degree of involvement of the other muscles If the posterior group alone is paralyzed the peroneus longus and tibialis posterior may be transplanted to take over the function of the paralyzed posterior group

Before executing any muscle transplants however it is necessary to correct the existent deformity This is accomplished by division of fascia and tendons plus the manipulative procedures described for *talipes cavus* In cases of severe deformity wherein the paralysis is more extensive, the deformity is first corrected and is followed by arthrodesis of the talocalcaneal talonavicular and calcaneocuboid *articulations. Surgery in this instance consists in a two-stage opera*tion first correction of the deformity and, second the fusion operation A single-stage operation is sometimes preferred This consists in removal of a wedge in the dorsum of the foot in the region of the navicular bone, which results in improvement in appearance and function but leaves a definitely shortened foot The same holds true for astragalectomy as a method of treatment

TALIPES ADDUCTUS

Talipes adductus is a deformity of the foot in which the fore part remains in the adducted position (Fig 102) It is a retention of the fetal position of the foot. The adduction of the forepart is retained and is sometimes associated with an internal rotation of the tibia Talipes adductus causes marked intoeing.

Symptoms. The symptoms are the so-called "pigeon toed gait and a tendency for the child to stumble over its own feet If the *condition has existed for several years there is usually rotation of* the tibia All the toes and all the metatarsal bones are in the adducted position The condition is usually bilateral one foot being worse than the other

Treatment Treatment consists in prophylaxis which requires early recognition of the deformity It must be distinguished from the normal inversion of the foot that occurs in very young children If there is a definite talipes adductus at two years of age attempts must be made to correct the position of the foot If there is an extreme position of adduction in early childhood this must be considered as talipes adductus unless there is a rapid spontaneous correction of the position

Conservative measures will usually suffice to correct the deformity The Hauser brace permits walking and keeps the foot in abduction It may also be worn at night, or splints may be used.

When the condition does not respond to ordinary conservative treatment and persists after five years of age, manipulation under anesthesia, using the triangular block (Fig 184), will be required. The foot is forced into extreme abduction After overcorrection has been obtained a cast is applied The position retained by the cast

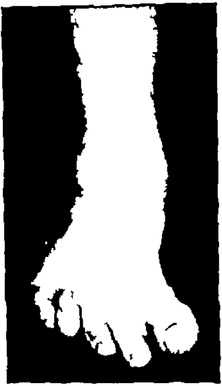


Fig 102. Congenital talipes adductus

has slightly less correction than was obtained by means of the manipulation

The child is not allowed to walk in the cast until full correction has been obtained if it is not accomplished with the first manipulation it is possible to take increased correction, usually without anesthesia and apply a new cast. The child walks with the cast in the overcorrected position for at least three, preferably six, weeks. If there is any tendency toward recurrence, the cast treatment is followed by a shoe so constructed that the anterior part of the foot turns out into abduction This is worn until there is no further tendency toward recurrence

METATARSUS VARUS

This term is limited to the congenital deformity in which there is an inward bowing of *the metatarsal bones (Fig 103) This forms* a true varus of the metatarsals The deformity is the same in appearance as *the talipes* adductus and is frequently included under that term The four medial metatarsal bones are involved the head of the first being displaced away from the head of the second In all probability the condition results *from a retention of the fetal posi*



Fig 103 Roentgenogram of congenital metatarsus varus

tion of the anterior part of the foot Since the bowing of the metatarsal bones, or the true varus is usually seen in older children it is possible that this is an adaptation of the bone to a congenital *talipes adductus deformity*

Symptoms. The most obvious deformity is the displacement of the head of the first metatarsal bone away *from the second* The roentgenogram shows the actual bowing in the sense of a varus of the metatarsal bones The cuneiform bones are also involved and the first cuneiform is usually underdeveloped and malformed There is a sharp angulation at the juncture between the first cune*iform and first metatarsal bones* The deformity usually shows itself

in the varus position of the great toe. The child walks with the foot turned inward and there is difficulty in purchasing a properly fitting shoe.

Treatment. In early childhood the foot is corrected by manual manipulation and held by a plaster of paris cast which goes from the toes to below the knee. Correction is increased gradually until overcorrection is obtained. Usually it is best to correct the foot under light anesthesia by manual manipulation over the triangular wedge. The foot is then held in position by a plaster of paris cast for four to six weeks.

In older children and when the first metatarsal bone shows severe bowing osteotomy at the base of the first metatarsal bone may be indicated. The metatarsal bone is then brought into normal alignment and fixed with a plaster of paris cast until union occurs.

In neglected cases with extreme deformity it may be necessary to perform osteotomy, removing a wedge from the outer side of the tarsometatarsal area.

TALIPES SUPINATUS

This is a congenital deformity of the foot in which the supinated position of the fetal foot is retained. Apparently there is an arrest in the embryologic development so that normal development from supination to pronation is hindered.

Symptoms. The anterior part of the foot is occasionally held in supination while the child walks. This means that the weight is borne on the outer side of the foot and the head of the first metatarsal bone does not touch the ground. Usually however the condition is not recognized in early childhood. After the child begins to walk, in order to assume weight bearing on the head of the first metatarsal bone the heel will be forced into valgus, so that talipes supinatus usually gives rise to pes valgoplanus. The condition is recognized by the inability to bring the anterior part of the foot into the normal position while the heel is being held in slight varus. The contracture is in the tarsal region. Contracture at the talonavicular articulation makes it impossible to bring the head of the first metatarsal bone on a plane with the fifth while the heel is held in slight varus.

Treatment. Early recognition and treatment are important since they prevent the development of pes valgoplanus and all its attendant complications. In early childhood, if there is sufficient deformity so that it can be recognized, the heel is held in varus while the anterior part of the foot is brought into pronation and a cast

is applied If the condition is diagnosed at the time the child begins to walk, which is usually the case, adequate correction can be obtained by means of the corrective shoe. The inner side of the heel of the child's shoe is raised ⅛- to ¼ inch The comma-shaped transverse bar is applied to the shoe, posterior to the heads of the four medial metatarsal bones and the outer side of the bar is raised ⅛ to ¼ inch In cases of longer standing the talipes supinatus has been overshadowed by the pes valgoplanus deformity, and correction of the talipes supinatus will be the same as described for the contracture and supinated position of pes valgoplanus

REFERENCES

Blumenfeld I., Kaplan, N., and Hicks, E. O The Conservative Treatment of Congenital Talipes Equinovarus. J Bone & Joint Surg., *28* 765 1946

Boehm M The Embryologic Origin of Clubfoot Trans by W B Blount J Bone & Joint Surg., *11* 229 1929

Browne, D Modern Methods of Treatment of Clubfoot Brit M J., *2* 570 1937

Curtis F E and Muro F Decancellation of the Os Calcis, Astragalus, and Cuboid in Correction of Congenital Talipes Equinovarus J Bone & Joint. Surg., *16* 110 1934

Forrester Brown M The Treatment of Congenital Equinovarus. J Bone & Joint Surg., 17·661 1935

Graham, J Treatment of Congenital Talipes Equinovarus Am J Surg *36* 339 1937

Haglund P Die Principien der Orthopaedie Jena G Fischer 1923

Hauser E. D W A Manipulative Method of Treatment for Recalcitrant and Neglected Clubfoot. J.A.M.A., 93·688 1929 Cohesive Bandage for Clubfoot in Newborn Infants J.A.M.A., *138* 19 1948

Macey H B Clubfoot S Clin. North America, *17* 1231 1937

Peabody C. W., and Muro F Congenital Metatarsus Varus J Bone & Joint Surg., *15* 171 1933

Whitman, R A Treatise on Orthopaedic Surgery 8th ed Philadelphia, Lea & Febiger 1927

12

CIRCULATORY DISTURBANCES

CHILBLAIN

(Pernio or Frostbite)

Chilblain is a swelling and inflammatory reaction that results from excess cold. It commonly affects the foot and occurs not only in winter but often in the cold damp weather of autumn. It usually is found where the circulation is poorest as, for instance, on the dorsa of the toes at the heads of the first and fifth metatarsal bones and at the posterior surface of the heel. The mildest result of exposure of the body to cold is the common chilblain. The condition, however, can go on to form vesicles and it may result in ulceration and ultimately give rise to gangrene.

Etiology. In addition to exposure to cold there is also a constitutional factor in the development of chilblain. The condition usually affects persons with anemia and poor muscle tone. It is particularly common in children and young women who have a low basal metabolic rate or ovarian hypofunction. There seems to be a vascular instability which is more appreciable in youth and gradually improves with the years. Peripheral circulatory disturbances also play a role. A tight shoe will tend to increase the frequency of the occurrence; a stocking that is too small can act in a similar way. Direct pressure on the skin causes local anemia, and venous stasis is frequently seen in connection with the chilblain.

Chilblain usually comes in cold, damp weather and disappears during warm weather. The swelling behaves like an inflammatory reaction. The arterioles contract as the result of exposure to cold and the blood supply to the peripheral capillaries is cut off. The capillary bed dilates. The peripheral congestion is seen as a swollen bluish area and during this stage there is a peculiar burning sensation although the skin is not sensitive to touch. With increased

warmth there is a rush of arterial blood into the capillaries and the foot becomes very painful. With this increased peripheral congestion there is exudation into the surrounding tissue. This may be of such a degree that the pressure will result in the formation of blebs and ultimately in ulceration As the swelling subsides an inflammatory reaction takes place *along with an infiltration followed* by an increase in fibrous tissue The skin itself as well as the subcutaneous tissues is involved in this inflammatory reaction

Symptoms. The symptoms of chilblain are the feeling of extreme coldness followed by numbness and tingling, and then, perhaps a short period during which sensation is lost. With the return to warmth the area assumes a cyanotic color and gradually there is a sensation of tingling and the pain may be extreme. Swelling increases in proportion to the extent of the original exposure. There is some itching of the skin over the area The danger of vesiculation and ulceration is that these may become infected The area remains sensitive to changes in environmental temperatures both heat and cold

Treatment The treatment consists first in prophylaxis This means the wearing of warm clothes and the avoidance of over exposure to extreme cold *Special care should be taken during the* cold damp weather of the autumn months Circulation can be improved by the use of the Pavex boot or some other form of intermittent venous occlusion and by massage of the foot and leg Prolonged use of water on the extremity should be avoided In addition treatment should be directed against the constitutional deficiency; haliver oil viosterol and calcium are indicated A high caloric and high vitamin diet is frequently recommended Endocrine deficiency may be corrected. The circulation will improve with the improvement in muscle tone, and graduated exercises are therefore prescribed

When the chilblain has developed it is well to put the patient to bed with the feet elevated and apply heat gradually At first the feet are left uncovered at room temperature while the rest of the body is kept warm The immediate application of heat must be moderate, since too much causes intense pain *The temperature may* be gradually raised to body temperature Local heat can be applied by the infra red lamp diathermy is dangerous since excessive heat should be avoided

If blebs form it is well to protect them from rupture If the skin is actually broken or if there is danger of breaking it it should

be cleansed thoroughly and covered with a sterile dressing. Any infection should be treated with the appropriate sulfa drug or antibiotic

To relieve the intense pain caused by the rapid inflow of the arterial blood the limb can be elevated or exposed to cold ranging from 60° to 40° F Compression may then be applied over the involved area to prevent the rapid return of the blood The Unna paste boot can be used in the same manner as a compression bandage a compression bandage would consist of sheet wadding snugly enclosed with a gauze bandage. Roentgen rays have been recommended as a means of giving relief and accelerating the subsidence of the symptoms If the wound is open silver nitrate may be used in connection with balsam of Peru For extreme pain the local use of ethyl chloride has been recommended

When the condition has existed for a long time, some have gone so far as to suggest bilateral lumbar sympathectomy especially if painful patches of erythrocyanosis are also present

TRENCH FOOT

Trench foot is a circulatory disturbance caused by prolonged exposure to wet and cold with infrequent change of foot covering It was prevalent during the World Wars among soldiers who were in the trenches in winter Lack of rest and continuous standing are also factors increasing this circulatory disturbance

Symptoms. The first symptom of trench foot may be paresthesia, later there is a severe burning pain The foot becomes swollen and the skin may either be blanched or show an erythema Cyanotic areas appear on the toes There is hyperesthesia in the erythematous swollen foot In the late stages peripheral neuritis and all its symptoms may be present In most extreme cases the toes are involved with ulceration or gangrene.

Treatment Treatment consists in rest in bed with elevation of the foot Lead and opium lotion may be used in the treatment of the erythematous type Aspirin and codeine are used to control pain As the circulation is gradually reestablished mild heat and gentle massage may be applied In other respects treatment is similar to that for chilblain

IMMERSION FOOT

Immersion foot is a circulatory disturbance similar to trench foot It was first described in World War II occurring in men

warmth there is a rush of arterial blood into the capillaries, and the foot becomes very painful. With this increased peripheral congestion there is exudation into the surrounding tissue. This may be of such a degree that the pressure will result in the formation of blebs and ultimately in ulceration. As the swelling subsides an inflammatory reaction takes place along with an infiltration followed by an increase in fibrous tissue. The skin itself as well as the subcutaneous tissues is involved in this inflammatory reaction.

Symptoms. The symptoms of chilblain are the feeling of extreme coldness followed by numbness and tingling and then perhaps a short period during which sensation is lost. With the return to warmth the area assumes a cyanotic color and gradually there is a sensation of tingling and the pain may be extreme. Swelling increases in proportion to the extent of the original exposure. There is some itching of the skin over the area. The danger of vesiculation and ulceration is that these may become infected. The area remains sensitive to changes in environmental temperatures, both heat and cold.

Treatment. The treatment consists first in prophylaxis. This means the wearing of warm clothes and the avoidance of over-exposure to extreme cold. Special care should be taken during the cold, damp weather of the autumn months. Circulation can be improved by the use of the Pavex boot or some other form of intermittent venous occlusion and by massage of the foot and leg. Prolonged use of water on the extremity should be avoided. In addition, treatment should be directed against the constitutional deficiency; haliver oil, viosterol and calcium are indicated. A high calorie and high vitamin diet is frequently recommended. Endocrine deficiency may be corrected. The circulation will improve with the improvement in muscle tone, and graduated exercises are therefore prescribed.

When the chilblain has developed, it is well to put the patient to bed with the feet elevated and apply heat gradually. At first the feet are left uncovered at room temperature while the rest of the body is kept warm. The immediate application of heat must be moderate since too much causes intense pain. The temperature may be gradually raised to body temperature. Local heat can be applied by the infra red lamp; diathermy is dangerous since excessive heat should be avoided.

If blebs form, it is well to protect them from rupture. If the skin is actually broken, or if there is danger of breaking it, it should

be cleansed thoroughly and covered with a sterile dressing. Any infection should be treated with the appropriate sulfa drug or antibiotic.

To relieve the intense pain caused by the rapid inflow of the arterial blood, the limb can be elevated or exposed to cold ranging from 60° to 40° F. Compression may then be applied over the involved area to prevent the rapid return of the blood. The Unna paste boot can be used in the same manner as a compression bandage; a compression bandage would consist of sheet wadding snugly enclosed with a gauze bandage. Roentgen rays have been recommended as a means of giving relief and accelerating the subsidence of the symptoms. If the wound is open, silver nitrate may be used in connection with balsam of Peru. For extreme pain, the local use of ethyl chloride has been recommended.

When the condition has existed for a long time, some have gone so far as to suggest bilateral lumbar sympathectomy, especially if painful patches of erythrocyanosis are also present.

TRENCH FOOT

Trench foot is a circulatory disturbance caused by prolonged exposure to wet and cold with infrequent change of foot covering. It was prevalent during the World Wars among soldiers who were in the trenches in winter. Lack of rest and continuous standing are also factors increasing this circulatory disturbance.

Symptoms. The first symptom of trench foot may be paresthesia, later there is a severe burning pain. The foot becomes swollen and the skin may either be blanched or show an erythema. Cyanotic areas appear on the toes. There is hyperesthesia in the erythematous swollen foot. In the late stages peripheral neuritis and all its symptoms may be present. In most extreme cases the toes are involved with ulceration or gangrene.

Treatment. Treatment consists in rest in bed with elevation of the foot. Lead and opium lotion may be used in the treatment of the erythematous type. Aspirin and codeine are used to control pain. As the circulation is gradually reestablished, mild heat and gentle massage may be applied. In other respects treatment is similar to that for chilblain.

IMMERSION FOOT

Immersion foot is a circulatory disturbance similar to trench foot. It was first described in World War II, occurring in men

who were marooned at sea in life rafts after shipwreck. This prolonged immersion of the extremities in cold or warm water produced symptoms similar to those in trench foot.

Treatment. The treatment is the same as that described for trench foot.

ERYTHROCYANOSIS OF THE LEG

Erythrocyanosis may be regarded as a form of chilblain; it is characterized by a cyanotic discoloration of the skin of the lower part of the leg. The condition is usually bilateral and affects young women. It is also seen, however, on poliomyelitic extremities. It is caused by exposure to cold, probably as a result of wearing short skirts and thin stockings.

Symptoms. The leg is usually enlarged as the result of an edematous infiltration in the subcutaneous tissue. The skin is cyanotic and shiny and may be infiltrated with small nodules. There is an inflammatory reaction around the hair follicles. The skin temperature is decreased and sensitivity increased. Friction rub may cause pain. The condition is due to dilatation of the small vessels and an inflammatory reaction of the skin and subcutaneous tissue. The pain during cold weather may be intense; it is increased on dependency of the foot and with walking.

Treatment. Relief is obtained by elevation of the limb and by the application of local and general heat. Hot packs followed by general massage relieve the symptoms and improve the circulation. Protection against cold prevents recurrence. The application of the Unna paste boot gives relief and permits the patient to be about but has the disadvantage of being unsightly, which may be a source of objection to young women. Sympathectomy should be reserved for the severe ulcerating forms of the condition.

THROMBO-ANGIITIS OBLITERANS

(Buerger's Disease)

Thrombo-angiitis obliterans is an inflammatory disease involving the peripheral arteries and veins which gives rise to symptoms of pain and gangrene. Intermittent claudication is a characteristic symptom and is associated with vasomotor spasm.

Etiology. The etiology is unknown. Predominant in the male sex, it occurs in certain families but is not hereditary. It is certain that it is an inflammatory process—probably infectious and perhaps the result of bacteria or toxemia. The frequency with which it affects

cigarette smokers and the fact that improvement is observed with cessation of smoking make this seem a contributing factor It is possible that the nicotine may have a temporary effect on the injured vessels causing a vasospasm and thus increasing the symptoms Not all the changes seen in Buerger s disease are permanent. The vasoconstrictive factor is a physiologic change and hence temporary rather than a part of the organic pathology Injury to the vessels due to exposure as well as strain has likewise been considered a causative factor

In this condition there is a chronic, relapsing patchy inflammation of the veins Changes occur in the intima of the vessels and consist in an increase in tissue which gradually closes off the vessel lumen This alteration in the lumen and the change in the flow of blood gives rise to thrombi which further occlude the vessels These thrombi become organized and may become canalized The middle and outer walls are also involved in the inflammation There is perivascular inflammation and the surrounding connective tissue is thickened. The inflammatory process involves not only the arteries but also the veins The nerves are sometimes also involved in the process of inflammation, and thus results in neuritis with degenerative changes

Symptoms. The symptoms are primarily due to vascular changes and the resulting insufficient blood supply to the tissues Circulatory balance is usually maintained because of the slow progression of the obliterative process.

Intermittent claudication is a primary symptom It consists in an aching, cramplike distress in the calf and is brought on by exercise and relieved by rest If walking is continued without rest the pain becomes intense There is also an alteration in the color of the skin of the foot With the foot elevated there is pallor with the foot dependent there is cyanosis The temperature of the involved extremity is lowered and the volume of the pulse is decreased Sometimes the pulse is not palpable in the tibialis anterior and sometimes not in the tibialis posterior There is frequently a change in the nails they become thickened and discolored.

When the condition is of long standing the circulation becomes more impaired cyanosis increases, and ultimately there is gangrene of the toes (Figs 104 and 105) In advanced cases there is pain even on standing or at rest in bed so intense that it is difficult to control with opiates The veins and arteries may be felt as hard, thickened cords The skin over the vessels is red and the area involved is tender When the occlusion is slowly progressive a dry type



Fig 104 Thrombo-angiitis obliterans showing cyanosis of the toes



Fig 105



Fig 106

Fig 105 Dry gangrene of the toes in thrombo-angiitis obliterans due to arteriosclerosis in a diabetic
Fig 106 Varicose ulcer

of gangrene occurs and the avascular tissue is gradually destroyed leading to spontaneous amputation When sudden arterial block is due to thrombosis the extremity becomes painful and the moist type of gangrene sets in

There are various tests for the diagnosis and estimation of the severity of the involvement A simple one is to elevate the limb and observe the pallor The limb is then allowed to drop and there is a gradual refilling with blood until the limb becomes cyanotic The length of time it takes for the reestablishment of circulation after the limb has been emptied is increased beyond that of the normal The temperature of the limb may be measured by a skin thermometer Roentgenograms show relatively little arteriosclerotic change

Treatment *Prophylactic Treatment* Prophylaxis consists in avoiding trauma as well as prolonged standing and walking particularly under conditions which involve exposure to dampness and cold Woolen hose are used to supply warmth and to support the vessels without constriction Exercises must be controlled and graduated so that they are within the limits of vascular ability In order to carry out some function walking must be interrupted sufficiently to allow for reestablishment of normal blood supply The feet are washed each night with soap and water and then dried with a soft cloth The skin is then rubbed with 70 per cent alcohol after which petrolatum may be applied Loose woolen hose may be worn in bed The use of an electric pad at night is dangerous and no strong medication should be applied to the skin of the foot Frequently the condition is complicated by a mycotic infection which has a tendency to increase the circulatory disturbance The mycosis must be treated without causing irritation (See Treatment of Dermatomycosis)

Local Treatment Local heat of a mild type is of value and may be applied in the form of moist packs and by the use of the infrared lamp The application of heat may be followed by light massage Great care must be exercised in applying heat since the skin is very sensitive This form of treatment is carried out in the early stages until the condition can be improved so that the patient can carry out active exercise

To improve the circulation contrast baths are indicated consisting of two pails of water one containing cold water and the other warm to hot water The foot is submerged for two to five minutes alternately in each pail the time of submersion in each depending on how long it takes for the foot to adjust itself to the hot or cold

water If the vasomotor disturbance is so great that the response to the change in temperature is not satisfactory these baths are contraindicated Intermittent positive and negative pressure is of benefit to increase the circulation and is applied by means of the pavex boot. The addition of a moderate amount of heat increases the effectiveness of the machine This heat may be applied directly in the machine or directly to the body while the machine is in use The rhythmic emptying and filling of the vessels increases the collateral circulation In a similar way *the opening and closing of the vessels* by the application of a blood pressure constrictor tends to allow the vessels to empty and fill an exercise which improves the blood supply to the limb Elevation and lowering of the limb by means of an overhead pulley is likewise a beneficial exercise

In the early stages reestablishment of normal gait by means of the corrective shoe has proved of value as a prophylactic measure In cases in which therapeutic measures have reestablished the foot *so that walking can be resumed the corrective shoe and normal* gait will tend to help prevent recurrences

General Treatment General treatment includes the forcing of fluids ten to twelve glasses of water daily being urged One hundred *and fifty grams of sodium chloride a day may be given in keratin* coated capsules The use of 150 to 300 cc. of sodium chloride solution injected intravenously has been recommended These measures help to increase the blood volume and possibly decrease the blood viscosity which has been high in some cases

Local infections should be treated Tobacco is prohibited particularly cigarette smoking When there is a tendency toward gangrene rest in bed is essential The presence of ulceration frequently causes extreme pain Such pain has a general effect on the patient interfering with eating and sleeping and increasing the danger of secondary infection Control of pain is therefore important in increasing general resistance

Good results have been reported with lumbar sympathectomy This is usually preceded by a paravertebral sympathetic block with procaine as a therapeutic test If this is effective the lumbar sympathectomy is done In performing a lumbar sympathectomy the preganglionic fibers to the part involved are divided while at the same time the postganglionic autonomic innervation is preserved This gives vasodilatation without the accompanying undesirable effects following a postganglionic sympathectomy The first lumbar ganglion is retained The sympathetic ganglia L 2 and L 3 make up the autonomic supply to the foot by way of the sciatic nerve

These ganglia may be excised unilaterally or bilaterally by either the abdominal or retroperitoneal approach The postganglionic innervation to the foot from the lower lumbar ganglia is retained.

The positive and negative pressure of a pavex boot has been found of some value in the restoration of the circulation

About twenty years ago it was a common experience to remove a toe or several toes because of gangrene or pain in this condition In many cases it was even necessary to amputate the lower extremity and in a good many of these it was necessary to go above the knee

My experience has been that in every case of Buerger's disease the patient had a mycosis usually a chronic infection and the most remarkable results have been consistently obtained by treating the mycosis (see page 346) I have found that the best exercise for the rehabilitation of circulation is correct gait If a pes valgoplanus is present mild correction is taken first by means of felt pads in the shoes followed by corrective shoes with the comma-shaped bar and Thomas heel (see Treatment for Pes Valgoplanus page 65) Since the use of this treatment amputation has not been found necessary When gangrene was present the circulation improved sufficiently so that the necrotic tissue sloughed off and healing took place

ARTERIOSCLEROSIS AFFECTING THE FOOT

The foot is involved in general arteriosclerosis This is a vascular change characterized by thickening of the intima and degenerative changes in the arterial walls A fatty degeneration occurs with replacement by scar tissue and calcareous deposits (Fig 107) These changes in the intima and vascular wall proceed without signs of any inflammatory reaction The veins are not involved.

Etiology Arteriosclerosis is a natural change as a result of age There is however an individual variation in the rate at which these physiologic vascular changes occur and there seems to be a diathesis toward arteriosclerosis However normal vessels may be influenced toward arteriosclerotic changes by infection as well as by other factors Special types of arteriosclerotic change are seen in cases of alcoholism lead poisoning, and gout Other factors which seem to increase these changes are high nervous tension and overeating and overwork. A special type of arteriosclerotic vascular change due to syphilis will be described later

Symptoms. The symptoms are due to an inadequate blood supply as a result of the narrowed lumen and thrombosis of the blood vessels Intermittent claudication occurs Muscle cramps are present after walking for a few minutes or on walking rapidly these cramps

may occur at night and interfere with sleep Tingling sensations and sensations of cold are frequently experienced The feet tend to become congested when dependent and blanched when elevated Recurrent phlebitis occurs The pulse is diminished and often lost *The arteries are palpable, and vascular changes are seen in the roentgenogram* Owing to the obstruction by the vascular disease or to the emboli gangrene may occur

Treatment. Treatment consists primarily in prophylaxis Excessive use of the feet as in prolonged walking and exposure to ex



Fig 107 Calcification of the digital arteries

tremely cold and damp weather should be avoided Frequent bathing and the use of cold cream to prevent drying of the skin are advised Small abrasions are washed with Emulsept or zephiran chloride 1 1000 or any of the accepted detergents or with soap and water and protected with a sterile bandage All infections should be treated as a serious complication

If necessary moist packs and rest in bed are used until all signs of infection have disappeared The use of alternating suction and compression with the Harris machine is of some value Heat and massage to the limb are beneficial Postural exercises like repeated elevation of the foot during the day are beneficial not only to pre

vent the occurrence of intermittent claudication but also to decrease the strain placed on the impaired vessels. Exercises within the limit of the vascular capacity are beneficial this means exercises to the point before claudication occurs.

Sympathectomy and foreign protein injections are not indicated

High cholesterol increases the lipoid deposit under the intima and thus leads to calcification In case the blood cholesterol is high a low-fat diet is advisable. Iodides may also lower the blood cholesterol

When the arteriosclerosis is complicated by varicose veins, treatment of the latter is said to show symptomatic improvement in the arteriosclerosis Occasionally with painful gangrene of the toes the peripheral nerve may be exposed and injected or divided.

DIABETIC ARTERIOSCLEROSIS AND GANGRENE

Peripheral arteriosclerosis involving the foot occurs in relatively young people in cases of diabetes The blood supply to the peripheral tissue is decreased as a result of the obstruction of the vessels. In some cases complete block occurs as a result of thrombosis. These arteriosclerotic changes are not always in direct proportion to the severity of the diabetes The devitalized tissue is more susceptible to infection, and its healing power is decreased

Complete block of the arterial supply may cause gangrene This gangrene, in its early stages, may be of the dry type it usually becomes infected however, and is of the moist type.

The impaired vascular supply makes the tissue more susceptible to injury and infection A burn or frostbite, a slight infection around the nail or an infection from trimming a corn may lead to a slow healing ulcer or to gangrene. Dermatomycosis of the toes often makes a point of entry for secondary infection which may ultimately lead to gangrene.

Treatment. Prophylactic treatment consists in control of the diabetes. Since the use of insulin the occurrence of gangrene has decreased. Further prophylaxis consists in avoiding trauma and in preventing infection The feet are washed thoroughly with soap and water daily and dried well, care being taken to prevent an abrasion of the skin in drying The skin is kept soft by rubbing the feet with mineral oil The nails are cut with care and straight across, avoiding using pointed scissors near the skin Chiropodists are warned to be careful in trimming calluses Friction rub from the shoe must be prevented

Electric pads hot water bottles or any form of intense heat is contraindicated

may occur at night and interfere with sleep Tingling sensations and sensations of cold are frequently experienced The feet tend to become congested when dependent and blanched when elevated Recurrent phlebitis occurs The pulse is diminished and often lost. The arteries are palpable and vascular changes are seen in the roentgenogram Owing to the obstruction by the vascular disease, or to the emboli gangrene may occur

Treatment. Treatment consists primarily in prophylaxis Excessive use of the feet, as in prolonged walking and exposure to ex



Fig. 107 Calcification of the digital arteries.

tremely cold and damp weather should be avoided. Frequent bathing and the use of cold cream to prevent drying of the skin are advised Small abrasions are washed with Emulsept or zephiran chloride, 1 1000 or any of the accepted detergents or with soap and water and protected with a sterile bandage All infections should be treated as a serious complication

If necessary moist packs and rest in bed are used until all signs of infection have disappeared The use of alternating suction and compression with the Harris machine is of some value Heat and massage to the limb are beneficial Postural exercises like repeated elevation of the foot during the day are beneficial not only to pre

vent the occurrence of intermittent claudication, but also to decrease the strain placed on the impaired vessels Exercises within the limit of the vascular capacity are beneficial, this means exercises to the point before claudication occurs

Sympathectomy and foreign protein injections are not indicated

High cholesterol increases the lipoid deposit under the intima and thus leads to calcification In case the blood cholesterol is high a low fat diet is advisable. Iodides may also lower the blood cholesterol.

When the arteriosclerosis is complicated by varicose veins, treatment of the latter is said to show symptomatic improvement in the arteriosclerosis Occasionally, with painful gangrene of the toes the peripheral nerve may be exposed and injected or divided

DIABETIC ARTERIOSCLEROSIS AND GANGRENE

Peripheral arteriosclerosis involving the foot occurs in relatively young people in cases of diabetes The blood supply to the peripheral tissue is decreased as a result of the obstruction of the vessels. In some cases complete block occurs as a result of thrombosis These arteriosclerotic changes are not always in direct proportion to the severity of the diabetes The devitalized tissue is more susceptible to infection and its healing power is decreased

Complete block of the arterial supply may cause gangrene. This gangrene, in its early stages, may be of the dry type; it usually becomes infected, however and is of the moist type

The impaired vascular supply makes the tissue more susceptible to injury and infection A burn or frostbite, a slight infection around the nail or an infection from trimming a corn may lead to a slow healing ulcer or to gangrene. Dermatomycosis of the toes often makes a point of entry for secondary infection which may ultimately lead to gangrene

Treatment Prophylactic treatment consists in control of the diabetes Since the use of insulin the occurrence of gangrene has decreased. Further prophylaxis consists in avoiding trauma and in preventing infection The feet are washed thoroughly with soap and water daily and dried well care being taken to prevent an abrasion of the skin in drying The skin is kept soft by rubbing the feet with mineral oil. The nails are cut with care and straight across, avoiding using pointed scissors near the skin Chiropodists are warned to be careful in trimming calluses. Friction rub from the shoe must be prevented.

Electric pads, hot water bottles or any form of intense heat is contraindicated

The same measures to improve the circulation in arteriosclerosis affecting the foot are used here. Since infection may be present, drainage of the infected area may be necessary. Moist heat with a baker and one or two lamps is of value. This heat should be slightly above body temperature.

It is sometimes necessary to amputate on account of the local gangrene; in most cases, however it is best to wait until spontaneous amputation takes place, guarding the area against infection. When the infection spreads, amputation may be necessary as a lifesaving measure. Amputation is usually high and without the use of tourniquet. It may be done under spinal anesthesia.

ENDARTERITIS DUE TO SYPHILIS

The peripheral arteries of the legs and feet undergo changes as a result of syphilis. There is round cell infiltration of the media, the elastic tissue being replaced by fibrous tissue. There is also an overgrowth of the intima. This proliferating endarteritis is associated with thrombosis. Periarteritis is also present, and may be primary.

Obliteration of vessels due to syphilitic endarteritis will manifest itself when advanced in gangrene or perforating ulcer. A positive diagnosis is made from the blood test or other clinical symptoms.

Treatment. Treatment is essentially the treatment for syphilis. Local treatment would be the same as for symptoms of vascular deficiency due to an obstruction. This would include the avoidance of strain, protection against extreme cold and particularly protection against secondary infection.

ACUTE ARTERITIS

An acute inflammation of the peripheral vessels in the foot occurs in acute infections such as rheumatic and typhoid fevers. The area over the artery is red and swollen. There is severe pain and the vessel is tender to pressure. The pulse may be lost and the limb below the obstruction becomes pale and cold. If the obstruction is extremely rapid, gangrene may follow; otherwise the collateral circulation becomes established to supply the limb adequately.

Treatment. Treatment is directed against the primary condition. Moist heat, not too intense, relieves the pain and ameliorates the inflammation.

PERIARTERITIS NODOSA

The small and medium sized arteries of the foot may be involved as part of a generalized lesion known as "periarteritis nodosa." The

inflammatory necrotizing lesion begins in the outer coat of the vessel and leads to thrombosis chronic perivascular infiltration and small aneurysm formation All stages of the processes may be found in a single vessel with intervening normal areas giving rise to the nodular feel of the vessel

The condition is probably an allergic manifestation of a chronic infection is frequently associated with rheumatic fever, and has been described in serum sickness and hypersensitivity to the sulfa drugs and iodine. Pain is present along the course of the vessels A diagnosis is made from the general symptoms if the disease is suspected and confirmed by microscopic examination of one of the nodules The general symptoms depend on the location of the pathologic conditions Systemic findings frequently include fever leukocytosis and albuminuria A marked eosinophilia may be present. Chronic bronchitis is evidence of lung involvement. Hematuria and high blood pressure speak for renal involvement. The prognosis is generally fatal and the treatment is symptomatic.

SUDDEN OCCLUSION OF THE ARTERIES THAT SUPPLY THE FOOT, DUE TO EMBOLISM AND THROMBOSIS

This is an unusual occurrence, but it has been reported. Most frequently the embolus in the lower extremity lodges at the bifurcation of the popliteal artery occasionally in the posterior tibial artery The symptoms are those of sudden obstruction of the blood supply Excruciating pain in the region of the embolus is followed by paralysis of the leg and foot The skin becomes cold and pale and the pulse is lost

Treatment Treatment consists in the immediate use of heat in a mild form with the limb slightly dependent. This heat should not be more than a few degrees above body temperature Alcohol gives temporary relief since it is an antispasmodic Opiates should be given to control the pain Papaverine hydrochloride, in ½ grain doses is injected intravenously to improve the peripheral circulation The alternating suction and pressure apparatus is indicated If possible embolectomy should be carried out before forty-eight hours have elapsed. When gangrene is present amputation may be carried out to prolong life

Arterial thrombosis may occur in the same area but it comes on more gradually The symptoms are similar to those of arterial embolism and may be seen in Buerger s disease or in pneumonia and typhoid fever

The treatment is the same as conservative treatment for embol

ism The operation of Leriche (periarterial sympathectomy) has been used to advantage to stop spasm of the vessel and to improve the condition

RAYNAUD'S DISEASE

Raynaud's disease is relatively rare and covers a number of conditions in which the characteristic feature is spasmodic discoloration of the fingers and toes due to disturbances in the vasomotor centers or pathways In cases of continuous vasoconstriction it may ultimately lead to symmetrical bilateral gangrene These changes occur in the presence of obliterative vascular changes in the peripheral vessels

Etiology The cause is not known The condition predominantly affects women and is frequently associated with neurasthenia. It is generally believed to be a disturbance in the sympathetic nervous system which has a lower threshold toward stimuli and whose activities are, therefore, increased. Some believe, however that the fault lies in an abnormal sensitivity of the vessels to cold.

Symptoms. In Raynaud's disease involving the foot the most frequent symptom is pallor of the toe followed by cyanosis Between these attacks of alternating pallor and cyanosis, the digits may assume normal color The attacks are brought on by exposure to cold or by an emotional upset. The malady may exist in a mild form for years there is some tendency toward progressive increase. Very mild forms may clear up entirely Attacks are also increased by emotional disturbances The condition is sometimes associated with scleroderma or it may result in sclerodactylia in the late stages

In its severe form the condition is extremely painful. The foot becomes cyanotic, and instances have been reported wherein the tips of the toes have become gangrenous These acute attacks have been reported to last for a period of months and result in loss of the toes

Treatment Exposure to cold, particularly over long periods as well as cold water bathing should be avoided. Tolerance to cold can be gradually built up The extremities should be kept warm woolen hose and generally warm clothing should be worn in winter If the extremity has been exposed to cold it must be brought back to the normal temperature gradually Special care should be taken to avoid possible abrasion and infection of the involved toes

The most striking results have been obtained by bilateral lumbar sympathetic ganglionectomy carried out by the transperitoneal route Gangrene rarely occurs in the foot in Raynaud's disease

Nevertheless the operation is indicated when the symptoms are severe and persistent and have a tendency to become progressively worse.

ERYTHROMELALGIA

This is an uncommon condition characterized by heat redness and pain in the extremities The cause is unknown It is often associated with polycythemia vera It is diagnosed by a characteristic burning distress when the temperature of the skin is elevated to a critical level

VARICOSITIES

A varicosity or varicose vein is a dilated vein which has become elongated and follows a tortuous course. It occurs anywhere in the body and often involves the leg and foot (Fig 108)

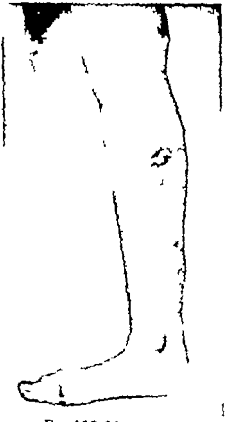


Fig. 108 Varicosities

Etiology Varicosities are common in adults occurring most frequently between the ages of forty and sixty years Heredity is an important factor They may develop as the result of an occupation

that requires prolonged standing Pressure in the veins causes distention of the walls because of weakness in the vascular structure or impaired tone of the surrounding muscles An important factor in bringing about varicosities is the loss of contracture in muscles of the leg such as occurs in the flatfooted gait in which the body weight is shifted from one foot to the other without using the foot as a propulsive agent. Loss of action of the leg muscles results in a loss of contracting power against the veins Varicosities are therefore frequently associated with impaired muscle tone of the leg and are seen with pes valgoplanus

The veins become dilated during pregnancy partly as a result of mechanical block from the enlarged uterus and partly because of venous hyperemia in the pelvis A disturbance in the innervation of the vessels may also be a causative factor As the vein is distended the valves which prevent the return flow of the blood are decompensated and there is a return flow in the vein which becomes further distended. The decompensation may be due to weakness rupture or destruction of the valves Deep respiratory movements accelerate the venous return and decrease the danger of thrombosis, so does the Trendelenburg position after operation A tight circular garter may be a factor in obstructing the superficial veins

Symptoms. The symptoms are a feeling of heaviness in the leg as well as pain after prolonged standing Large, convoluted veins are apparent under the skin when the patient stands The thickened bluish enlarged coils of the saphenous vein can be seen through the skin The peripheral veins are enlarged and can be palpated easily A plexus of small veins may be seen around the ankle over the dorsum of the foot as well as up in the popliteal space and over the leg. There is an edema in the region of the ankle. The skin gradually becomes thickened and hardened. In cases of inflamed veins of long standing the skin becomes red or assumes a peculiar brownish color The discoloration may be the result of repeated inflammatory reactions in which the small vessels of the skin break and exudates of blood enter the skin For treatment see Varicose Ulcers

VARICOSE ULCERS

Etiology and Symptoms. If a thrombus occurs in a varicose vein there is a tendency if the patient is up and about, for it to become localized in a peripheral vein and this may account for the sudden development of a varicose ulcer In the presence of varicose veins the blood in the limb does not enter the heart and lung and become

oxygenated and the circulation of this impure blood with its high carbon dioxide content gives rise to toxic effects on the tissues in the surrounding area. The skin becomes thin, the fatty tissue is lost and the muscles become atrophic. The walls of the vessels are altered and one can no longer differentiate the various layers. Normal structures are replaced by connective tissue. There may be an overgrowth of the muscle layer and elastic fibers but without normal arrangement so that degenerative changes are taking place at the same time that regeneration occurs. Frequently a small, straight vein runs alongside the coiled varicose vein and carries the blood to the heart.

The longer the condition exists, the more alteration is observed in the valves of the veins. The veins become thin and permeable, and blood enters the subcutaneous tissue, causing discoloration. The veins frequently become inflamed, and thrombophlebitis results.

Sudden obstruction of a vein will cause edema and loss of normal vascular supply over a long period ultimately gives rise to ulceration. Lack of a normal blood supply results in necrosis of the tissues. A slight irritation or a superficial abrasion results in a chronic ulcer (Fig. 106). There is infiltration of the surrounding structures of the ulcer and absence of healing. The ulcer finally becomes infected, and one sees small areas of pus in an area of reddened, infiltrated ulceration. The secretions from such an ulcer, if they lie on the skin, ultimately lead to an eczematous irritation. The process can go on until the infected area spreads and the thrombi in the veins extend higher to the thigh.

Treatment. Treatment consists in increasing the muscular activity of the leg and improving the circulation by deep breathing exercises, and in supportive treatment for the veins. Treatment for varicose veins as well as for varicose ulcers and thrombo-angiitis of the vein and secondary edema consists in use of the Unna paste boot, intravenous injections, and surgical correction.

Exercises. Exercises for the leg may be carried out in the recumbent position. The patient lies on an inclined bed, the foot of which is raised about 6 inches. A pulley weight of approximately 15 pounds is attached to a stirrup. The foot is then passed through the stirrup and counteraction is obtained by pulling against the weight. The exercises are carried out daily for periods of about seven minutes each time. If this procedure is not practical, elevation of the bed is of value but must be accomplished without flexing the knee. A pillow under the knee would tend to interfere with return flow. Deep breathing exercises are of value in the treatment of varicose

veins The increase in intra abdominal pressure tends to empty the veins in the abdomen With expiration there is a negative intra abdominal pressure and the veins of the lower extremity drain into the iliac veins and vena cava

Compression of Vascular Walls Compression of the vascular walls by means of an elastic stocking tends to increase the efficiency of the valves It is difficult to adapt an elastic stocking to the thigh The rubber stocking is efficient when new but has the disadvantage that it does not retain its elasticity long in addition it is not porous Woven stockings are useful in the milder cases They have the advantage over rubber ones in that they are porous and allow free perspiration Elastic bandages may also be used. The Martin bandage causes too much discomfort, when used for even short periods of time it should be perforated Ordinary woven bandages, such as Ace or Tetra are more satisfactory The disadvantage of these is that they have a tendency to loosen as the muscles are used in walking and they then begin to slip In order to have the bandage on satisfactorily it must be reapplied at least twice a day To apply the bandage, it is started over the forepart of the foot, run over the middle, then over the ankle, and up over the leg

Strapping When varicosities and varicose ulcers occur with foot strain and pes valgoplanus, adhesive strapping may be used to advantage. A Gibney bandage, which runs well up over the leg and covers at least the lower two-thirds is applied with the heel held in varus position (Fig 177)

In addition to the elastic support for the veins of the leg, a moist marine sponge or a rubber sponge may be applied over the vein in the thigh and fastened with a bandage or adhesive tape. This sponge acts as an artifical valve. In a similar way, a sponge may be applied directly over the devitalized skin or the varicose ulcer in the leg.

Unna Paste Boot. In the treatment of varicose veins and also varicose ulcers, thrombophlebitis of the vein and edema secondary to the varicosity the most important therapeutic measure in my experience, is the Unna paste boot along with correct gait The skin and ulcer must be prepared before the Unna paste boot can be applied. If the infection is extreme and if there is generalized infiltration with obvious pus the whole area is washed with Lmul sept and zephiran chloride, 1 1000 The foot is elevated daily and warm moist boric dressings and controlled heat are indicated preferably with hospitalization After the infection has subsided the ulcer may be treated with an Unna paste boot

The skin is first shaved and the area around the ulcer covered with Lassar's paste. The cleaned ulcer is covered with sterile gauze. With the boot on the secretions from the ulcer which are not absorbed by the gauze cannot irritate the surrounding skin, which is covered with the Lassar's paste. The patient is then taught to walk with normal gait while wearing the boot Use of the muscles gives a contracting force against the walls of the semielastic boot, so that there is a compression force which acts to pump the blood from the veins If there is excessive secretion an opening may be made in the boot, over the ulcer and the sterile bandage changed

As granulation forms in the ulcer epithelialization is still slow The granulation fills in from the bottom and during this stage the wound is frequently painful The ulcer and surrounding discolored skin are painted with a 2 per cent solution of gentian violet

The boot is changed as it becomes loose or worn which may take anywhere from one to four weeks It is sometimes necessary to use as many as three or four boots before complete healing is obtained. The edema is then decreased and the veins are definitely improved The individual veins are felt as hard firm pencil like cords The thrombi become organized and complete obstruction of the dilated vein is obtained

When the response to this type of treatment is not satisfactory it must be kept in mind that other factors may be involved, the principal ones to be considered being syphilis impairment of arterial circulation a skin defect too large to heal without skin graft or surrounding tissue that is too fibrous or phlegmonous

Use of the limb is not only permissible but essential in carrying out satisfactory treatment

There are cases in which the distention of the veins is so great and the valves so incompetent that treatment with the Unna paste boot is not sufficient For these cases surgical intervention is indicated

Injection Treatment Injection treatment consists in the use of a substance which will produce thrombosis and obliteration of the varicose veins It is carried out with the patient ambulant. Various types of sclerosing substances are used sodium morrhuate, 5 per cent (2 to 5 cc) has given good results 50 per cent dextrose or 20 per cent sodium chloride solution with some type of anesthetic has also been used

Potassium oleate in 5 or 10 per cent solution is injected in quantities of 0 5 to 2 cc two to four injections may be necessary The vein is first emptied so that the injected substance may come in

contact with the wall and the limb is then elevated The needle enters the distended vein pressure is applied distal to the needle, and the blood is then drained out peripherally The injection is then made and thrombosis occurs. New varicosities may appear in the veins surrounding the thrombosed vein The thrombi are usually about 5 to 10 cm long

It is sometimes necessary to give as many as ten injections. The injection material should not be introduced around the vein since it may give rise to necrosis of connective tissue In case this occurs, the immediate injection of the patient's own blood into the blanched area is useful A necrosed area may be excised and the wound closed

In injecting into the great saphenous vein it is best to do so just below the knee if the injection is made in the thigh it should be limited to the small veins

It must be remembered in obliterating varicosities by surgery or an ulcer or of phlebitis This treatment is contraindicated in cardiovascular disease active tuberculosis, hyperthyroidism and acute infections

Surgical Procedures Surgical procedures are occasionally indicated High ligation of the saphenous vein will sometimes cure venous dilatation Usually ligation of this vein is carried out in conjunction with the injection treatment of the veins in the leg. The vein is exposed near the sapheno-femoral junction for a distance of 1½ inches All tributaries in this area are ligated and this segment of the vein is removed. The ends are ligated and the ligatures anchored by transfixion sutures The sclerosing fluid may then be injected into the vein The veins in the thigh are sometimes removed with a stripper but this increases the danger of pulmonary embolism

It must be remembered in [illegible] iterating varicosit[illegible] by surgery or injection that the treatm[illegible] symptom[illegible] underlying cause which may bring [illegible] ence of [illegible] dition must also be treated When po[illegible] tions th[illegible] mechanical strain should be avoided

rest in bed abdominal distention and shallow breathing and stasis occurs in the veins of the lower extremities Changes in the composition of the blood that make for thrombosis are an increase in the blood platelets and higher viscosity The composition of the blood is altered after major operations infections and childbirth Blood vessels are altered locally as a result of injury or infection and as was seen in the case of arteriosclerosis, as a result of changes in their walls

Symptoms. The symptoms depend on the vein involved Thrombosis may occur in the saphenous vein producing an inflammation of the vessel with redness and local tenderness The leg is painful particularly on walking There is usually a slight increase in temperature. The symptoms gradually disappear, only to recur

This condition is similar to thrombo-angiitis obliterans The wall of the vein may become thickened and the section involved is easily palpable Sometimes a small section of the vein is involved and as this subsides, the phlebitis may occur in a different part of the same limb (phlebitis migrans)

Thrombosis may occur in varicose veins. If it is sudden the circulation may be impaired so that there is a tendency toward ulcer Thrombosis of the vein usually results in a painful inflammation The thrombosed section is easily palpable The tissues surrounding the vein are also inflamed (periphlebitis) The lymph channels in the area are involved in the inflammatory process which results in edema The thrombus is usually infected. There is fever and an increase in the pulse rate

Thrombophlebitis may occur in the deep vein usually with sudden onset and a rise in temperature The pain is frequently extreme and is followed by rapid swelling of the extremity There is periphlebitis and early involvement of the lymph vessels The swelling has a tendency to persist giving rise to so-called milk leg.'

Treatment *Prophylactic Treatment* As preventive measures against thrombophlebitis, early movement and deep breathing have been suggested Local infection should be eradicated, since it is a causative factor In the presence of an acute thrombophlebitis however removal of the infections in other parts of the body would have a tendency to increase the thrombophlebitis, and this is dangerous While the patient is in the horizontal position the lower limbs should be elevated.

Once thrombophlebitis has occurred the danger of emboli must be kept in mind. If it is necessary for the patient to stay in bed it

contact with the wall and the limb is then elevated The needle enters the distended vein pressure is applied distal to the needle, and the blood is then drained out peripherally The injection is then made and thrombosis occurs New varicosities may appear in the veins surrounding the thrombosed vein The thrombi are usually about 5 to 10 cm long

It is sometimes necessary to give as many as ten injections The injection material should not be introduced around the vein, since it may give rise to necrosis of connective tissue In case this occurs the immediate injection of the patient s own blood into the blanched area is useful A necrosed area may be excised and the wound closed.

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It must be remembered in obliterating varicosities by surgery or injection that the treatment is only symptomatic The underlying cause, which may bring about a recurrence of the symptoms must also be treated When possible occupations that lead to mechanical strain should be avoided

THROMBOPHLEBITIS

A thrombus may occur in the veins of the lower extremities It is practically always associated with inflammation of the vein—thrombophlebitis The thrombus is usually infected

Etiology There are three principal factors in the etiology slowing of the circulation change in the composition of the blood and alteration in the wall of the vessel The circulation is impeded by

rest in bed, abdominal distention and shallow breathing, and stasis occurs in the veins of the lower extremities. Changes in the composition of the blood that make for thrombosis are an increase in the blood platelets and higher viscosity. The composition of the blood is altered after major operations, infections and childbirth. Blood vessels are altered locally as a result of injury or infection and, as was seen in the case of arteriosclerosis, as a result of changes in their walls.

Symptoms. The symptoms depend on the vein involved. Thrombosis may occur in the saphenous vein, producing an inflammation of the vessel with redness and local tenderness. The leg is painful particularly on walking. There is usually a slight increase in temperature. The symptoms gradually disappear, only to recur.

This condition is similar to thrombo-angiitis obliterans. The wall of the vein may become thickened, and the section involved is easily palpable. Sometimes a small section of the vein is involved and, as this subsides, the phlebitis may occur in a different part of the same limb (phlebitis migrans).

Thrombosis may occur in varicose veins. If it is sudden, the circulation may be impaired so that there is a tendency toward ulcer. Thrombosis of the vein usually results in a painful inflammation. The thrombosed section is easily palpable. The tissues surrounding the vein are also inflamed (periphlebitis). The lymph channels in the area are involved in the inflammatory process, which results in edema. The thrombus is usually infected. There is fever and an increase in the pulse rate.

Thrombophlebitis may occur in the deep vein, usually with sudden onset and a rise in temperature. The pain is frequently extreme and is followed by rapid swelling of the extremity. There is periphlebitis and early involvement of the lymph vessels. The swelling has a tendency to persist, giving rise to so-called milk leg.

Treatment. *Prophylactic Treatment.* As preventive measures against thrombophlebitis, early movement and deep breathing have been suggested. Local infection should be eradicated, since it is a causative factor. In the presence of an acute thrombophlebitis, however, removal of the infections in other parts of the body would have a tendency to increase the thrombophlebitis and this is dangerous. While the patient is in the horizontal position, the lower limbs should be elevated.

Once thrombophlebitis has occurred, the danger of emboli must be kept in mind. If it is necessary for the patient to stay in bed, it

may be safer for him to sit up so that a loose thrombus would tend to localize in a peripheral vein During the acute stage hot applications and rest are essential

Unna Paste Boot In superficial thrombophlebitis in the leg the Unna paste boot may be applied even during the active phase. Walking is begun at once. This method has been proved safer than treatment by rest in bed.

Ligation of Saphenous Vein When the vein in the thigh is involved and there is rapid spread of the thrombosis it may be necessary to tie off the saphenous vein at the sapheno-femoral junction in order to prevent a fragment of a thrombus from escaping and forming an embolus Such involvement is sometimes benefited by repeated small doses of roentgen rays As soon as the acute inflammation in the thigh has subsided the Unna paste boot should be applied and walking is encouraged.

General Measures In the treatment of thrombophlebitis of the deep veins the patient is kept in bed with the limb slightly elevated and moist heat is applied, using the baker To dissolve the thrombus, anticoagulants are used. Because dicumarol requires approximately forty-eight hours to increase effectively the coagulation time of the blood, heparin may be administered concurrently during that first period A prothrombin time is always taken before treatment is started In acute cases, to increase immediately the coagulation time of the blood, heparin in doses of 100 mg is given intravenously every four hours if the initial prothrombin time is above 70 per cent. If it is below 70 per cent, 50 mg every four hours are administered. This same dose may be continued for forty-eight hours if the prothrombin time remains above 20 per cent By the end of this forty-eight hour period the dicumarol will have become effective in increasing the coagulation time. In an average-sized adult 300 mg are administered the first day; the second day 200 mg are given and daily prothrombin times will determine subsequent doses. Approximately 50 mg daily is the maintenance dose. The prothrombin time should be maintained at approximately 20 per cent of normal a standardized serum is used as the normal or 100 per cent In chronic cases the heparin may be omitted.

As the infected thrombus dissolves bacteria are released into the blood stream These are combated by the daily administration of sufficient penicillin to maintain adequate levels 300 000 units of penicillin in procaine peanut oil combination twice a day have proved to be an adequate dose

After the acute symptoms have subsided an Unna paste boot may

be utilized from the toes to the knee, and a compression bandage is applied to the thigh. The limb may be encircled with two or three layers of sheet wadding and held by a Tetra bandage 3 inches wide.

Emphasis is placed on the use of the Unna paste boot and early walking, particularly in cases of the recurrent, chronic and migrating types of thrombophlebitis of the leg.

LYMPHEDEMA OF THE FOOT AND LOWER EXTREMITY

Lymphedema is a swelling due to interference with the drainage of lymph.

Etiology. There are several types of lymphedema: occasionally it is congenital, and there is a type that occurs during the adolescent period, particularly in females. The flow of the lymph may be obstructed owing to an inflammation of the lymph channels secondary to cellulitis, and lymphedema may likewise occur as the result of secondary infections which begin in the foot. It may also be the result of an obstruction near the nodes due to malignancy in the nodes, or to be due to their surgical removal.

Symptoms. The congenital type is a lymphedematous swelling involving chiefly the foot and leg. The entire limb may be hypertrophied. The tissues are relatively soft.

Adolescent lymphedema, so-called lymphedema praecox, is a symptom complex which occurs in females, usually during the age of puberty. There is gradual swelling without apparent cause, and generally both legs are affected. The swelling may be limited to the foot and ankle. There is a tendency for the swelling to decrease when the foot is elevated. The chief complaint is the unsightly appearance. The condition seems to be worse before and during the menstrual periods.

Lymphedema occurring secondary to an inflammation of the lymph channels comes on suddenly, with chills and fever. It is the result of a streptococcic infection. After the acute inflammation subsides, the lymph vessels are thrombosed and there is lymphostasis with an increase in the size of the limb.

Recurrent attacks of lymphedema of the foot and ankle are sometimes seen in the presence of dermatomycosis. It is possible that the mycotic infection may permit entrance of a secondary infection through the skin. In any case there are apparently recurrent attacks of obstruction of the lymph channels. Obstruction of the lymph channels as a result of filariasis, which is a tropical disease, is *not* a common cause of the lymphedema seen in this country.

Lymphostasis may occur in the lower extremity as the result of

obstruction of the lymph nodes. This usually occurs in the inguinal region and frequently is the result of malignancy, surgical treatment of these nodes, or treatment by roentgen rays or radium.

When the lymphedema has persisted a long time, there is swelling of the calf and loss of contour at the ankle; the limb assumes the shape of a column. The skin itself is edematous and pale. There is thickening of the fascia and infiltration of fibrous connective tissue. The tissue is resistant to pressure (Fig. 109).

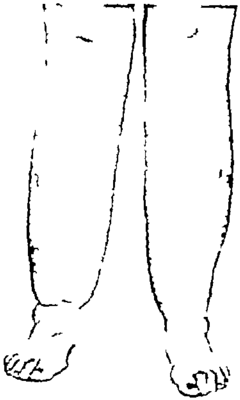


Fig. 109. Lymphedema of the lower extremities, edema due to obstruction in the inguinal region. There is enlargement of the osseous structures as well as of the soft tissues.

Treatment. *Early Lymphedema.* In the early stages of lymphedema, fluid can be mobilized by maximal elevation of the limb. The patient is put on a salt free and dry diet; potassium chloride may be used to replace table salt. To eliminate fluid, ammonium nitrate, 7½ grams three or four times daily, is prescribed. Salyrgan or mercupurin may be used, 1 ampule of 2 cc. intravenously as required, is given once or twice a week, depending on the effect. The intake of fluid is limited to about 1500 cc. but not restricted enough

to cause thirst The guide to effectiveness is a decrease in swelling loss of weight and increased urinary output.

The longer the lymphedema is present the more difficult it is to treat therefore, early elimination of the lymphostasis is important To permit the patient to be up and to prevent an increase in swelling the limb is wrapped with a bandage made of pure rubber This bandage is 3 inches wide and is wrapped around the entire length of the lower extremity It is best to wrap it over a stocking The bandage must be neither too tight nor too loose if it is too tight it will interfere with circulation and if it is too loose it will permit edema

Acute lymphangitis should be treated by means of hot packs rest and elevation of the limb In addition sulfa drugs and penicillin are of value The mycosis should be treated.

In lymphedema praecox when the lymphedema is definitely increased before the menstrual period emmenin may be tried

Chronic Lymphedema A long-standing lymphedema offers a difficult problem The Unna paste boot is of no value in this condition Mustard plasters have been used to soften the skin a thick paste of mustard flour is made with lukewarm water applied to a bandage, and fastened to the skin (Hohmann) Hyperemia follows and the skin can tolerate the plaster for only about five minutes This treatment is repeated each day and the period of application is gradually increased until the skin can tolerate it for a half hour After several weeks a chronic hyperemia manifests itself The skin becomes soft and the subcutaneous tissue gradually shrinks The limb is then wrapped with a pure rubber bandage, which is left on for a period of ten minutes to a half hour The bandage is loosened as soon as paresthesias develop To obtain results this treatment requires a period of at least six months

Surgical Treatment Surgical treatment consists in a Kondoleon operation or preferably the procedure described by Macey The principle of these operations is the removal of tissue to decrease the size and to obtain drainage through the deep lymph channels

Good results have been reported following Macey s operation This consists in elevation of the extremity for two days before surgery The medial and lateral aspects of the leg are operated on in two stages Large skin grafts are taken from the thigh or the leg if the latter is not involved in the disease process An incision is made from the knee to the forepart of the foot extending in depth through the skin subcutaneous tissue and fascia Dissection is carried anteriorly and posteriorly leaving a thin layer of areolar tissue

obstruction of the lymph nodes This usually occurs in the inguinal region and frequently is the result of malignancy surgical treatment of these nodes or treatment by roentgen rays or radium

When the lymphedema has persisted a long time, there is swelling of the calf and loss of contour at the ankle; the limb assumes the shape of a column The skin itself is edematous and pale. There is thickening of the fascia and infiltration of fibrous connective tissue The tissue is resistant to pressure (Fig 109)

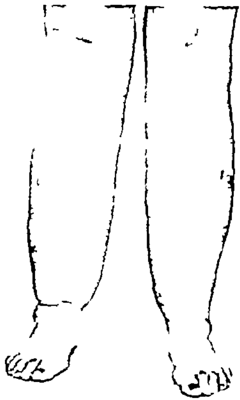


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covering the muscles, tendons and periosteum The previously pre pared intermediate thickness skin grafts are sutured in position beneath the elevated lymphedematous tissue This tissue is then closed over the grafts and a compression bandage is applied. On the seventh to ninth postoperative day the lymphedematous tissue is excised and the margins are sutured to the edges of the grafted area Mild compression over the grafts is continued for ten to twelve weeks The second stage of the operation is not performed until four months have intervened.

REFERENCES

Allan, F N Diabetic Gangrene., S Clin. North America, *16* 1701 1936

Allen, E. V., and Ghormley R K Lymphedema of the Extremities Etiology Classification and Treatment, Report of 300 Cases Ann Int Med 9 516 1935

Bell, F McK. Effects of Wet and Cold Trench Feet Canad. M.A.J., 6 289 1916

Curtis, G M Diseases of the Lymphatic System, in Christopher F., editor A Textbook of Surgery 4th ed Philadelphia, W B Saunders Company 1945 p 251

de Takáts, G Acute Arterial Occlusion of the Extremities. Am J Surg., 33 60 1936. Vascular Accidents of the Extremities J.A.M.A., *110* 1075 1938

Herrmann L. G Passive Vascular Exercises. Philadelphia, J B Lippincott Co., 1936 Clinic on Peripheral Vascular Diseases Internat Clin., 3 171 1937

Hohmann G. Fuss und Bein 2 Aufl, Munich J F Bergmann 1934

Leriche R. The Surgery of Pain (Trans by Archibold Young) Baltimore The Williams & Wilkins Co., 1939

Macey H B A Surgical Procedure for Lymphoedema of the Extremities. J Bone & Joint Surg., 30 339 1948

Miscall L. Frost Bite. S Clin North America, *17* 303 1937

Ochsner A., and DeBakey M Thrombophlebitis The Role of Vasospasm in the Production of the Clinical Manifestations J.A.M.A *114* 123 1940

Scupham, G W Therapy of Arterial Thrombosis of the Extremities J.A.M.A., *104* 1229 1935

Smith L. A., and Allen, E. V Erythermalgia of the Extremities Am Heart J., *16* 175 1938

Webster D R. Woolhouse, F M., and Johnston J L. Immersion Foot J Bone & Joint Surg., 24 785 1942

Whitney F T., and Consales P A The Treatment of the Varicose Ulcer New England J Med., *213* 967 1935

Willauer G Ambulatory Treatment of Varicose Veins S Clin North America *16* 621 1936

13

FRACTURES OF THE FOOT AND ANKLE

FRACTURES OF THE ANKLE JOINT OR OF THE MALLEOLI

A fracture at the ankle joint may involve either the medial or lateral malleolus or both Occasionally a fracture of the medial malleolus is associated with a fracture of the fibula in its lower fifth The fragments may or may not be displaced. If they are, there is certain to be a subluxation of the talus In addition, there may be an associated separation between the tibia and fibula with tearing of the tibiofibular ligament. If the lateral malleolus is fractured and the internal lateral ligament torn, there is certain to be subluxation of the talus If the fibula is fractured above the level of the ankle joint with displacement of the talus, there is inevitably a separation between the tibia and fibula and the ligaments will be torn

In severe injuries both malleoli may be fractured in addition, there is separation of a fragment from the posterior surface of the tibia (Fig 110) Injuries are usually associated with a posterior dislocation The joint surface of the ankle may also be injured with involvement of the anterior tibial surface These fractures may occur without displacement of fragments, or there may be displacement so severe as to result in an upward and posterior dislocation of the talus Sometimes both malleoli may be fractured and the position of the talus altered, and yet the articular surface formed by the tibia and fibula may remain intact When the tibiofibular ligament is torn and there is a gap between the tibia and fibula, there is distortion of the upper surface of the ankle joint. This in itself is a severe injury whether associated with a fracture or not.

Fractures of the ankle may be accompanied by fractures of the upper end of the fibula These frequently go unnoticed Original X ray studies should include the entire leg

Etiology Fractures at the ankle joint usually occur as the result of a violent sudden twist in which the body weight exerts an ab-

normal force at the ankle, either with the foot in adduction and the heel in varus or with the foot in abduction and the heel in valgus causing fracture either of the lateral malleolus or of the medial malleolus respectively In addition to the force caused by the body weight there may be an increased force due to falling from a height

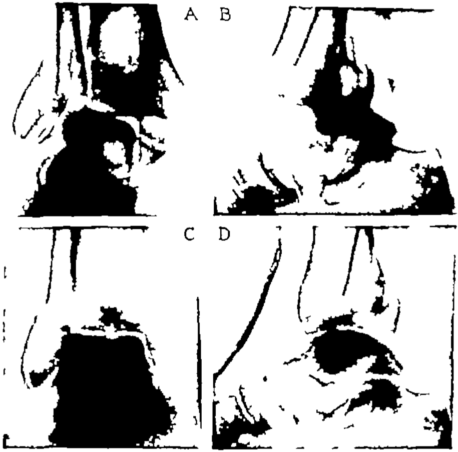


Fig 110 Fracture of the malleoli with displacement of the ankle joint A, Anteroposterior view Note the displacement of fragments and particularly the alteration of the joint surface *B* Lateral view showing the dislocation and separation of a fragment from the posterior surface of the tibia C Anteroposterior view after reduction *D* Lateral view after reduction

If the force is extreme, both malleoli will give way if it comes from above as in a fall with the heel either in varus or in valgus the additional force tends to fracture the posterior fragment and to increase the displacement of the talus

Symptoms. The injury usually occurs suddenly and is associated with some shock The symptoms are pain swelling and tenderness over the area of fracture and over the area of the torn ligaments If

there is dislocation the deformity is noticeable; the distortion is evident when there is a posterior displacement. Swelling occurs soon after the injury regardless of whether or not subluxation is present. If there is displacement the swelling is generalized throughout the entire ankle joint; if not, it appears at the site of the fracture, over either the medial malleolus or the lateral malleolus. This may be followed by an effusion into the ankle joint with distention and further swelling.

If injury has caused separation of the tibiofibular ligament with a gap between the two bones the amount of pain and swelling is apparently out of proportion to the injury. This will cause lateral motion at the ankle joint. Since the upper surface of the ankle joint is distorted this is a serious and painful condition although the fracture seen in the roentgenogram may seem insignificant. The effusion and hemorrhage into the joint are very marked in this type of injury. Motion at the ankle joint is painful. If there is a displacement of the talus any motion will cause pain but even without displacement motion that puts tension at the site of the fracture will give rise to pain. The fractured areas are definitely tender. Effusion or hemorrhage that causes tension of the joint is easily palpable. Pressure will increase the tension and therefore increase the pain. The joint is usually held fixed by reflex muscle spasm.

The diagnosis is definitely established by means of roentgenograms together with the history and findings.

Treatment. Treatment consists in reduction, fixation and early functional use; it should be instituted as soon after the injury as possible.

Reduction. The earlier the fracture is recognized the simpler will be reduction. Roentgenographic examination should be made routinely to see if there is any displacement of fragments or any dislocation. Exactness of diagnosis is important in carrying out the treatment accurately. The most serious disabilities are due to unrecognized fractures which have been allowed to remain unreduced.

The fracture is more readily visualized when the foot has been relaxed as, for example, after the injection of a local anesthetic. If it is seen soon after the injury and if there is intra-articular hemorrhage adequate anesthesia usually can be obtained by infusing the joint with novocain, about 20 cc. of a 2 per cent solution ordinarily being sufficient. If the injury is limited to the malleoli these are injected separately. Gentle pressure is exerted over the injected area to diffuse the anesthetic to all the injured structures. As the novocain takes effect the pressure is continued so that the fluids which cause

the swelling are gradually pressed upward into the subcutaneous tissue. This decreases the size of the ankle until the malleoli are visible. General anesthesia may be used in carrying out the reduction

When there is displacement of fragments and dislocation reduction must be carried out under anesthesia either general or local, depending on the circumstances under which the operator has to work. In hospital practice, where ethylene is easily obtained at all hours general anesthesia is simple. The dislocation is reduced the fragments are brought into alignment and molded into position and the reduction is held either by a plaster of paris cast or by a molded plaster splint and muslin bandage. Roentgenographic examination follows the reduction If the reduction is not satisfactory the procedure must be repeated until satisfactory position has been obtained

A malleolar fracture without displacement is relatively rare and requires only adequate fixation in the position of choice. Extreme supination often recommended is ill advised inasmuch as it increases the tibiofibular separation it is this separation that gives rise to functional disturbance. Furthermore if the heel is brought into varus, it must be remembered that the anterior part of the foot should not be permitted to go into supination since with fixation in the tarsal area a compensatory valgus and pronation of the foot will result. With a supination contracture of the anterior part of the foot the calcaneus will be forced into a valgus position when the head of the first metatarsal bone is placed on the floor The position of choice is therefore one in which the foot is at about a right angle at the ankle joint with neither valgus at the heel nor supination of the anterior part of the foot. However the position of choice should not be taken at the expense of displacement of fragments

In eversion fracture involving the medial malleolus the patient s knee is flexed and the foot held at a right angle to obtain reduction this gives the maximum amount of relaxation While one hand holds the tibia firmly on the medial side, the other hand presses the ankle from the lateral side, exerting a force on the foot and talus in a medial direction This corrects the valgus deformity It is not possible to overcorrect by means of this maneuver With the heel in the midposition or slight varus the anterior part of the foot is brought into pronation until it reaches a normal relationship to the heel This position is then held with a cast

When only the lateral malleolus is fractured reduction is accom

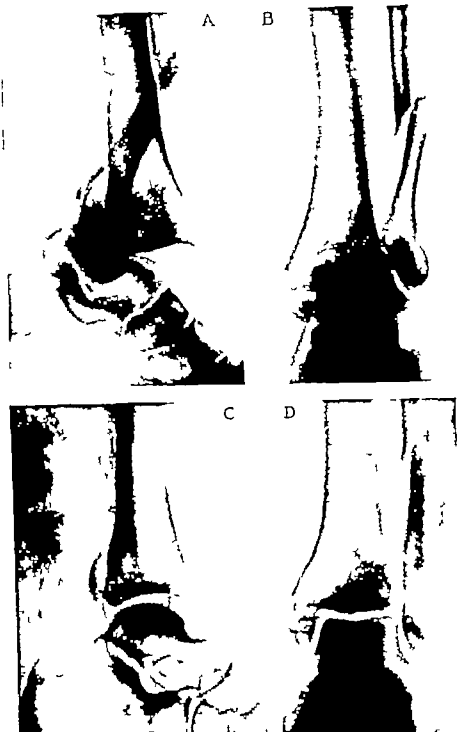


Fig 111 Fracture of the medial malleolus and the fibula with posterior dislocation at the talocrural articulation A, Lateral view B anteroposterior view There is a separation between the tibia and fibula and an alteration of the talocrural articulation C Lateral view after reduction taken through cast D anteroposterior view after reduction, taken through cast

plished by compression of both malleoli and the foot is put up in the midposition by means of a plaster of paris cast.

If both malleoli are fractured and there is a valgus deformity at the ankle, reduction is obtained with pressure exerted from the lateral side of the ankle and a resistant force exerted medially against the tibia To retain the reduction the foot is held in the midposition as before, with the exception that a moderate degree of plantar flexion may be necessary while the cast is applied

In bimalleolar and posterior lip fracture with posterior dislocation relaxation is obtained with the knee in flexion Extension is applied to the foot and heel and with pressure from the hand holding the tibia on the anterior surface, force is exerted on the heel from behind in an anterior and plantar direction The talus is reduced and cannot be displaced anteriorly If the posterior dislocation is associated with lateral displacement, pressure must be exerted from the lateral surface at the ankle while the tibia is held from the medial side as well (Fig 111) The reduction can then be obtained and the cast applied from the the toes to above the knee It is necessary in order to facilitate retention of position while the cast is being applied to allow the foot to be in varying degrees of plantarflexion and the knee in a flexed position to relax the gastrocnemius

Fixation Equal in importance to complete reduction is absolute retention best accomplished by a form fitting plaster of paris cast applied directly to the skin If the position of the fragments can be retained while the cast is being applied the circular cast is most effective. A double layer of sheet wadding may be used to protect the heel and over the dorsum of the foot to protect against swelling and interference with circulation

In severe injury or if the cast has been applied soon after the injury the cast should be split on the anterior surface immediately after application If swelling becomes marked and if the circulation is interfered with the cast can be separated easily to relieve pressure. In most cases suspension of the limb for forty-eight hours will prevent swelling and the necessity for splitting the cast When severe swelling is not expected the cast need not be split but in any case precaution should be taken against unforeseen swelling This means that the house surgeon should be instructed to cut the cast if there is any interference with circulation

In some cases it is preferable to obtain fixation by means of a posterior molded splint of plaster applied directly to the skin The fold that occurs in the plaster at the ankle joint may be excised and

then molded until smooth, or it may be cut through and the upper flap molded to the skin and the lower flap allowed to overlap and be molded to the foot Molding of the splint continues until the plaster is hard This splint is held in place with a muslin bandage. When the swelling has subsided, fixation obtained by the splint may be further reinforced by a plaster bandage, so that the limb is enclosed in a complete cast

Restoration of Function The patient remains in bed until there is no sign of shock The foot is elevated to prevent further swelling and is kept quiet until the pain has subsided The swelling usually reaches its height in twenty four to forty-eight hours it then gradually decreases until the cast becomes loose If the swelling is insignificant, a walking caliper may be applied to the cast and walking begun immediately after the pain subsides If there is much swelling and retention of the fragments is simple the cast may be changed as soon as the swelling subsides and weight bearing begun by means of the walking caliper If it is difficult to retain the position of the fragments it may be well to keep the limb at rest in the original cast until some callus is formed, so that there will be no displacement of fragments at the time the new cast is applied

In no case should weight bearing be permitted on a cast that allows movement between the fragments

Walking is begun as soon as fixation by means of cast is certain The caliper may be applied and if there is some plantarflexion the caliper should be a little higher than that ordinarily used. The walking caliper is molded to the hard cast and attached by means of plaster of paris The object of the caliper is to make locomotion possible and at the same time to protect the cast The position of the caliper therefore, should be in the same axis as the midline of the leg To prevent the caliper from marring the floor or from slipping a piece of firm rubber is usually attached to it

In some cases a heel attached to the cast will have the same effect as the caliper and permit normal walking This heel can be made of felt leather, wood or a section of rubber tire, and it is fastened with plaster of paris bandage

Fixation by means of the plaster of paris cast is retained for three to twelve weeks depending on clinical and roentgenographic reports After this an Unna paste boot may be applied and corrections put into the shoe that is felt pads are applied inside the shoe as in the case of pes valgoplanus After a few weeks the corrective shoe with the external corrections may be used With resumption of the nor

mal rolling gait, functional reestablishment of the foot and ankle occurs In most cases heat and massage are not necessary; in certain cases, however they are a valuable adjunct

FRACTURES OF THE CALCANEUS

Fracture of the calcaneus presents a serious surgical problem It involves a bone that is essential in weight bearing it involves the articular surface of the talocalcaneal articulation, and it affects the longitudinal arch of the foot and impairs normal function. There may be a compression fracture of the body of the calcaneus, a fracture of the sustentaculum tali or there may be a fragment anterior to the tendo achillis so-called 'avulsion fracture. Both the method of treatment and the prognosis depend upon the type of fracture present.

Fracture of the Body of the Calcaneus. *Etiology* Fracture of the body of the calcaneus usually results from a sudden fall in which the body weight is transmitted through the heel The fall is generally from a great height, although fractures of the calcaneus have been reported from a fall of only 4 feet A sudden crash against the foot board of an automobile or airplane may result in compression of the calcaneus

Symptoms The symptoms include pain in the heel, which usually persists for some time in spite of any treatment Compression of the calcaneus results in loss of the normal depression beneath the lateral malleolus immediately after the injury After this soft tissue swelling involving the heel ankle and tarsal area appears and may persist for several weeks A hematoma usually develops with discoloration of the skin and rapid bleb formation The compression results in a broadening and flattening of the heel with loss of the longitudinal arch The severity of the symptoms varies of course, with the extent of injury

Sometimes the fracture line is without displacement or appreciable compression On the other hand there may be several fragments and a definite impaction with alteration of the surface of the talocalcaneal articulation Severe compression fractures of the calcaneus may be associated with a compression fracture in the last dorsal or first lumbar vertebra In healing a callus forms on the side of the bone usually under the lateral malleolus and if compression is permitted to persist this callus interferes with movement at the ankle joint and causes pain Projections that develop on the plantar surface of the calcaneus if allowed to remain will

give rise to pain on weight bearing A lateral or dorsal displacement of the fragments tends to bring the heel into valgus, an important factor in bringing about pes valgoplanus

Treatment Early recognition is important in the treatment of these fractures since many of the bad results occurred in cases in which the diagnosis was not made until some time after the injury The roentgenogram establishes the diagnosis and the type of frac

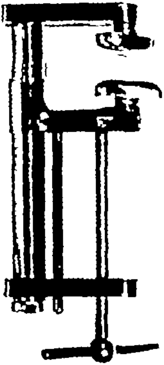


Fig 112 Compression type of apparatus (Bohler) used for lateral reduction of the calcaneus.

ture It also determines whether or not the articulation is involved, whether the plane of the articulation is in normal position, whether the compression is appreciable, whether there is a displacement of fragments, and whether the alignment of the calcaneus has been distorted so that the weight bearing transmitted to the foot must of necessity be altered

REDUCTION Treatment is directed against the structural disturbance. Occasionally the fracture line is such that no manipulation is necessary, in which case fixation is carried out immediately In most cases an anesthetic is necessary If a local anesthetic is used, it is injected at the site of the fracture line; should a hematoma be

present as much blood as possible is withdrawn after which 10 to 30 cc. of 1 or 2 per cent novocain are injected If the reduction is carried out under general anesthesia ethylene is preferable.

With the knee flexed extension is applied to the heel. The foot is in plantarflexion to relax the tendo achillis Traction can be applied manually and if the reduction is simple, the extension is held and the heel is brought into slight varus while the posterior splint is applied and molded The posterior splint can then be fastened with a muslin bandage and this in turn covered with encircling plaster of paris bandages (Böhler) or a cast may be applied



A B

Fig 113 A, Postero-anterior view of fracture of the calcaneus B after reduction with compression apparatus

directly to the skin with a small amount of sheet wadding to protect the dorsum of the foot The cast may start at the toes and go well up over the thigh If it stops below the knee an elevation splint is used to retain the flexion of the knee and hip The knee is flexed and the foot held in plantarflexion to keep the tendo achillis relaxed and to hold the corrected position of the calcaneus After removal of the cast an Unna paste boot is applied to prevent swelling The boot may be worn for several weeks At the same time the corrective shoe with felt pads applied inside is worn and normal gait is gradually reestablished If the heel is sensitive, sponge rubber may be placed in the heel of the shoe

In many cases it is necessary to break down the interlocking of the fragments This is done by means of a Thomas wrench or the

Böhler type of compression apparatus (Fig 112) The compression apparatus is used not only to correct the broadening of the fractured calcaneus and to prevent the formation of overgrowths on the lateral side in the form of exostoses but also as a mechanism to execute leverage in breaking up the compression (Fig. 113) Once the fragments are loose, they are extremely mobile, and reduction may be accomplished The posterior splint or cast is applied as described above while the lower fragment of the calcaneus is held

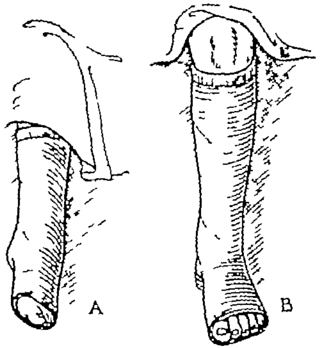


Fig 114 A, Sketch of cast with the heel in varus and the anterior part of the foot in supination which will ultimately lead to pes valgoplanus; B correct position of the foot in cast.

in extension As much dorsiflexion is taken as can be done easily (up to 90 degrees) provided the reduction of the fragment can be retained

When the fragments cannot be reduced by manipulation and manual reduction it may be necessary to use a Kirschner wire through the distal fragment by means of which direct traction can be carried out and a cast applied. The wire may be incorporated in the cast A caliper may be applied to the lower fragment to obtain direct extension After the reduction is accomplished and the cast is set the tongs may be removed The Böhler apparatus and the various modifications of it are mechanical measures which are useful in obtaining accurate reduction

In reducing fractures of the calcaneus it is well to keep in mind the importance of the relative positions of the calcaneus and the talus It is at the talocalcaneal articulation that the valgus deformity occurs in cases of pes valgoplanus The heel must be held in slight varus so that the normal relationship of this articulation is reestablished For the retention of normal position of the heel it is important also to see that the anterior part of the foot is held in its proper relationship namely, that the head of the first metatarsal bone is brought down into pronation This assures the presence of normal arches and of normal weight bearing through the foot (Fig 114)

FIXATION With reduction accomplished and the foot in normal position fixation is the next important measure in order that the functional exercise of walking may be carried out early Fixation is accomplished by means of the posterior molded splint which is retained with an encircling cast, or by means of a light, form-fitting plaster of paris cast applied directly to the skin without padding It is usually necessary to retain some plantarflexion of the foot to hold the calcaneal fracture in position A caliper is applied to the cast so that the foot clears the ground to permit walking As soon as the fragments are united sufficiently so that the foot can safely be brought to a right angle a new cast is applied with the foot in the midposition

RESTORATION OF FUNCTION After the foot has been brought up to or near a right angled position a heel can be applied to the cast to permit normal walking without the use of the caliper It is possible for a patient with bilateral fracture of the calcaneus to walk in this type of cast without the use of crutches The cast is worn for six to twelve weeks When removed the position of the heel is retained by means of adhesive strapping and felt pads in the shoe The adhesive strapping runs from the outer side of the heel over the plantar surface of the foot to the medial side of the leg A slight varus position of the heel is retained in this way The anterior part of the foot is then brought into pronation by running two strips of adhesive tape, each 1 inch wide, from the dorsum of the head of the first metatarsal bone over the medial margin of the foot across the plantar surface of the anterior arch and over the lateral margin up to the medial side of the ankle Several layers of sheet wadding protect the medial and lateral margins as well as the dorsum of the foot so that circulation is not hindered The felt pads in the shoe are designed with an inclined plane to the lateral side in the longitudinal pad and an inclined plane medially in the anterior

pad, to help retain the normal position of the foot. Walking is then resumed with this type of support

After ten days to three weeks the foot is held in corrected position with alterations on the outside of the shoe The heel is raised $\frac{3}{16}$ inch on the inner side, and the anterior bar is raised $\frac{3}{16}$ inch on the outer side Normal gait is then taught. The amount of exercise is limited at first and increased gradually until normal capacity has been established

DIRECT EXTENSION In severe compressions it may be necessary to obtain reduction by means of direct extension This is accomplished with a Steinmann pin driven through the posterior part of the cal caneus With the knee at a right angle, traction is applied Screw traction with measurement of force by means of the spring scale, can be used after the manner of Böhler Traction is applied through



Fig. 115 Fracture of the calcaneus without displacement.

a caliper attachment to the Steinmann pin in the calcaneus With the limb in a Braun frame, 8 to 10 pounds of traction are applied so that the pull is downward and posteriorly The broadened calcaneus is compressed and the valgus deformity altered into slight varus position by means of the Böhler type of compression apparatus

After the reduction a cast which includes the Steinmann pin is applied Fixation is held by means of the cast for a period of three months The pin may be removed at the end of three weeks and a plaster of paris cast applied directly to the skin A walking caliper can be attached to the cast and weight bearing begun at this time. After the cast is removed, the Unna paste boot is used and felt pads are applied in the shoe, followed by corrections on the outside of the shoe and reestablishment of the normal gait. Strength is re established gradually and it may take three months or longer before normal function can be carried out

Old Fractures of the Body of the Calcaneus. *Treatment* Occa sionally a fracture of the calcaneus goes unrecognized A compres sion fracture with malposition at the talocalcaneal articulation may

be present which causes pain on weight bearing Even with good reduction of the fragments of the body of the calcaneus there may be an alteration in weight bearing at the talocalcaneal articulation



Fig. 116 Healed fracture of the calcaneus with supination of the anterior part of the foot causing pes valgus result of incorrect position in treatment There was persistent pain in the heel which was relieved with correction of the deformity *A*, Roentgenogram of healed fracture *B* supination of the anterior part of the foot *C* valgus deformity of the heel

with continuous pain (Fig 115) There may be a compression with valgus position and exostoses beneath the lateral malleolus which result in pain Usually the mechanical irritation at the talocalcaneal articulation will give rise to traumatic arthritis The alteration may include the talonavicular articulation which also will show arthritic changes

An analysis must be made of the cause of the disability In most cases there is a valgus position with altered weight bearing at the talocalcaneal articulation and a resultant pes valgoplanus. The altered position is corrected either by conservative or manipulative measures.

MANIPULATION Sometimes the heel can be brought into varus and the anterior part of the foot into pronation by manipulation without anesthetic (Fig 116) This is usually done under anesthesia how ever and the Thomas wrench is used gradually to bring the heel



A B

Fig. 117 Fracture of the os calcis with *A*, valgus deformity *B* fracture into the talocaneal joint

into varus while the special lever is used to bring the anterior part of the foot into pronation The foot is brought into a position of overcorrection and the cast can then be applied with the foot in midposition without danger of pressure Weight bearing is assumed as soon as the pain subsides usually in one to four days Walking is then carried out with a caliper or heel attached to the cast The cast is worn for three to six weeks after which the corrective shoe is utilized and normal gait reestablished.

TALOCALCANEAL ARTHRODESIS When it is impossible to reestablish normal position at the talocalcaneal articulation by manipulation and when this articulation continues to be the source of painful irritation talocalcaneal arthrodesis is indicated Before fusion is carried out the normal position must be reestablished between the

talus and the calcaneus If the alteration at the talocalcaneal articulation is associated with a disturbance at the calcaneocuboid articulation, the latter should also be fused In this case the talonavicular articulation is also involved and subjected to additional strain so that this articulation too must be fused.

An exostosis which interferes with the lateral malleolus should be removed at the same time the fusion operation is performed If the exostosis alone is the source of complaint changing the valgus position of the heel into a varus position will be adequate to relieve the irritation and symptoms The problem becomes more complicated if the talocalcaneal articulation is fused with the heel in valgus position (Fig 117)

Fractures of the Sustentaculum Tali Fracture of the sustentaculum tali is rare It is the result of a sudden downward force on the foot with the heel in varus position The talocalcaneal articulation is usually involved

Symptoms The principal symptom is a sharp pain on the medial side of the foot which is increased with an attempt at weight bearing or on lateral motion of the heel There is usually some swelling over the medial side of the anterior part of the heel with an area of tenderness below the medial malleolus The diagnosis is made by roentgenogram Sometimes the fracture occurs without displacement, in which case it is difficult to recognize unless the roentgenogram is taken to show the sustentaculum tali

Treatment If there is displacement of the fragment treatment consists in manipulation to assure a normal relationship between the calcaneus and the talus The heel is held in varus position while the anterior part of the foot is brought into pronation at the same time the foot is brought into slight plantarflexion Pressure may be exerted dorsally just anterior to the heel With the foot held in this position a plaster of paris cast is applied from the toes to below the knee. A walking caliper may be attached and weight bearing begun after about seven days The cast is removed after about six weeks and the corrective shoe is worn with the heel supinated and the transverse bar raised on the outer side

In cases without displacement the heel is held in slight varus with the anterior part of the foot in supination and the foot at a right angle A plaster of paris cast is then applied and the walking caliper utilized so that walking may be begun at once The cast is left on for six weeks

If the injury to the talocalcaneal articulation is severe and pain

persists despite conservative treatment fusion of this articulation is indicated

Avulsion Fractures of the Calcaneus. An avulsion fracture of the calcaneus is usually caused by a fall from a height with the foot in plantarflexion the weight striking the anterior part of the foot. A duck-bill shaped fragment may be separated from the calcaneus just anterior to the insertion of the tendo achillis

Symptoms There is tenderness over the area of the insertion of the tendo achillis The patient is unable to stand on the toes of the foot involved Plantarflexion usually causes pain

Treatment If the fracture is slight and there is little displacement, protection by means of a plaster of paris cast is sufficient If the fragment is displaced, reduction or removal is necessary, under general anesthesia With the knee flexed and the foot in plantarflexion, the fragment frequently falls into position However, it may be necessary to exert pressure by manual manipulation, just anterior to the tendo achillis Occasionally when there is a large fragment and reduction cannot be obtained by manipulation it is advisable to replace the fragment by an open operation and fasten it by means of a small nail

It is often better to remove the fragment to prevent the occurrence of an enlargement in the region of the attachment of the tendo achillis into the calcaneus This is done through a longitudinal incision just anterior to the tendo achillis After reduction the lower extremity is put in a cast and plantarflexion of the foot is retained as well as flexion at the knee to keep the fragment in place The plaster of paris cast runs from the toes to well above the knee The position of the fragment is retained for a period of ten days to three weeks A new cast can then be applied with the foot at a right angle to prevent contracture of the tendo achillis, the cast extending from the toes to below the knee A walking caliper is attached and weight bearing is started immediately This cast is removed after a period of about three to four weeks

FRACTURES OF THE TALUS

Fractures of the talus may be classified clinically as fractures of the body of the neck, and of the posterior process These fractures are relatively rare and occur as a result of force transmitted with a torsion twist through the heel, as in falling Occasionally, extreme and sudden plantarflexion will fracture the posterior projection of the talus

talus and the calcaneus If the alteration at the talocalcaneal articulation is associated with a disturbance at the calcaneocuboid articulation, the latter should also be fused. In this case the talonavicular articulation is also involved and subjected to additional strain so that this articulation too must be fused.

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Symptoms There is tenderness over the area of the insertion of the tendo achillis The patient is unable to stand on the toes of the foot involved Plantarflexion usually causes pain

Treatment If the fracture is slight and there is little displacement, protection by means of a plaster of paris cast is sufficient. If the fragment is displaced reduction or removal is necessary under general anesthesia With the knee flexed and the foot in plantarflexion, the fragment frequently falls into position However it may be necessary to exert pressure by manual manipulation, just anterior to the tendo achillis Occasionally, when there is a large fragment and reduction cannot be obtained by manipulation, it is advisable to replace the fragment by an open operation and fasten it by means of a small nail

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Fractures of the Body of the Talus. *Symptoms* The symptoms of this condition are pain on weight bearing pain on movement at the ankle joint and pain at the talocalcaneal articulation There is limitation of motion and usually some swelling in front of and to the side of the ankle, more on the lateral than on the medial side The roentgenogram establishes the diagnosis

Treatment SIMPLE FRACTURES. In a simple fracture of this type, that is one without compression there is no need for reduction The leg is put in an unpadded plaster of paris cast and a walking caliper is applied As soon as the pain and swelling have subsided sufficiently to permit weight bearing walking is begun The cast is worn for a period of six weeks and is followed by the application of an Unna paste boot and the use of the corrective shoe. After removal of the Unna paste boot, physical therapy is carried out This consists in moist heat followed by massage in order further to mobilize the articulation and relax the muscles if they have become strained

COMPRESSION FRACTURES In a compression fracture of the body of the talus when there is a great deal of displacement there is also an alteration of the articular surfaces which would ultimately give rise to a very painful joint. Reduction can sometimes be obtained by direct extension A Steinmann pin is passed through the calcaneus and traction is applied The foot is held in plantarflexion, and traction is in a line 45 degrees posterior to the axis of the tibia A movable caliper is then fastened to the Steinmann pin and pulleys and weights are utilized for traction The leg is elevated on a splint with the knee held in flexion Traction is continued for a period of four to six weeks After the extension is removed the limb is held in position for weight bearing by means of a cast extending up over the knee. This cast should be form-fitting and applied directly to the skin A caliper should be applied to the cast and weight bearing started gradually After another six weeks period the cast may be removed and an Unna paste boot applied Felt supports are put in the shoe, and normal walking is gradually reestablished with the corrective shoe as an additional aid In spite of the best treatment however arthritic changes may occur as a result of injury of the articulation

Unreduced compression fractures of the body of the talus may give rise to severe disability Weight bearing and motion are painful Astragalectomy or removal of the talus, leaves a severely impaired foot Occasionally an open operation may be indicated to remove a disturbing fragment at which time an attempt should be made

to correct the position of the other fragments This operation should be carried out immediately after it has been established that satisfactory reduction is not obtainable by any other means This operation does not apply for neglected cases The pain may be in the talocrural articulation with limitation of dorsiflexion or it may be in the talocalcaneal articulation with limitation of lateral motion at the heel. If the pain is limited to the talocalcaneal articulation, this joint should be fused The fusion however should not be carried out until sufficient time has elapsed to be certain that conservative measures such as were described for fracture of the cal



Fig. 118 Healed fracture of the neck of the talus

caneus with involvement of this articulation will not be effective. If the roentgenogram shows some changes in the talonavicular or calcaneocuboid articulations, these should be fused at the time of the talocalcaneal arthrodesis If the talocrural articulation is involved every attempt should be made to attain proper alignment between the calcanus the talus and the weight bearing line of the tibia In this way strain is avoided and irritation is reduced to a minimum The heel of the shoe is raised to permit rolling off the affected foot with greater ease and to compensate for limitation of motion that may have occurred at the talocrural articulation

If the condition cannot be relieved by any of these conservative measures and if the pain is severe fusion of the articulation or astragalectomy may be resorted to

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If the condition cannot be relieved by any of these conservative measures and if the pain is severe, fusion of the articulation or astragalectomy may be resorted to

Fractures of the Neck of the Talus. *Symptoms* In this condition there is usually a deformity just anterior to the lower end of the tibia. The tarsal area seems to project upward. Swelling and tenderness are present just anterior to the ankle The roentgenogram establishes the diagnosis The fracture, as seen by roentgenogram, may be a simple oblique line without displacement, or it may be a transverse line with upward displacement of the anterior fragment. Occasionally the fracture line runs obliquely and posteriorly, and the anterior fragment is depressed while the posterior fragment is rotated.

Treatment NO DISPLACEMENT OF FRAGMENTS If there is no displacement of the fragments all that is necessary is immobilization by means of a plaster of paris cast up to the knee. Weight bearing can be begun as soon as swelling and pain have subsided sufficiently so that it can be carried out comfortably (Fig 118)

DISPLACEMENT OF ANTERIOR FRAGMENT If there is displacement of the anterior fragment, it is corrected by bringing the foot into extreme plantarflexion over a wooden wedge and exerting traction to the toes direct pressure is then exerted against the anterior fragment from above to obtain reduction The Thomas wrench may also be used to force the fragment into position one arm should extend below the posterior part of the calcaneus while the other lies on the dorsal surface, over the displaced anterior fragment This gives increased power to force the fragment back into position When the fracture is reduced it usually is possible to bring the foot up to a right angle without displacement and a plaster of paris cast can then be applied The cast is split if necessary on account of swelling The foot is then elevated, and no weight bearing is permitted for a period of two to four weeks, after which a plaster of paris cast is applied directly to the skin and a walking caliper is attached Weight bearing is then started gradually and the cast is worn for four to six weeks

DISPLACEMENT OF POSTERIOR FRAGMENT If the posterior fragment is displaced reduction is more difficult With the knee flexed the foot is forced into plantarflexion and traction is applied to the heel. Pressure is exerted against the talus by means of the thumb and finger forcing it anteriorly and being careful not to allow the heel to go into a position of valgus A plaster of paris cast is applied with the foot in plantarflexion and is worn for a period of two to three weeks before being changed The foot is brought to a right angle and a new cast is applied directly to the skin A walking caliper may be attached and weight bearing is begun gradually after about four weeks The cast is worn for another two to four weeks and is

followed by an Unna paste boot, which is worn for ten days to two weeks

Fractures of the Posterior Process of the Talus *Symptoms* The symptoms are pain just posterior to the ankle, and swelling and tenderness over this area Pain is increased with extreme motion at the ankle. The roentgenogram shows the fracture of the posterior process. This must be differentiated from the normal os trigonum which occurs in the same area

Treatment The foot should be immobilized in a plaster of paris cast. The cast should be applied directly to the skin and a heel or walking caliper attached as soon as it is hard. Weight bearing may be begun at once, and fixation should be carried out for a period of about four weeks

A chip fracture of the talus may occur in connection with the tearing of the lateral ligament. If adequate treatment is directed against the sprain, a satisfactory result will be obtained No additional treatment is necessary for this type of fracture

Occasionally a fracture occurs along the anterior margin of the tibia as a result of extreme forceful dorsiflexion This injury is followed by an overgrowth along the anterior margin of the ankle on the upper surface of the neck of the talus in the same area These exostoses prevent normal dorsiflexion Irritation may arise with motion and cause pain Treatment consists in removal of the marginal overgrowth and the exostotic ridge on the talus

FRACTURES OF THE TARSAL BONES

Fractures of the Navicular Bone. A fracture of the navicular bone occurs as the result of a fall with the foot in plantarflexion, as when wearing high heeled pumps it may be associated with a fracture of the talus Sudden hyperextension with the foot in equinus position has a tendency to displace the navicular bone dorsally The ligaments may tear and the displacement may be accompanied by chip fractures of the cuneiform bones and talus This is a compression type of fracture in which the force is transmitted along the first metatarsal bone from below and along the head of the talus from above. There may be a fracture line through the body of the navicular bone a dorsal fragment may be broken off or the bone may be compressed (Fig 119)

Symptoms The symptoms are pain swelling and tenderness over the navicular bone. The pain is increased on weight bearing and motion in the tarsal area There is a tendency to pronate the foot. Occasionally a fragment is separated and displaced medially and

downward to form a painful protuberance The diagnosis is made by means of roentgenograms

Treatment NO DISPLACEMENT OF FRAGMENTS If there is no displacement the foot is brought into the midposition which means slight varus of the heel and supination of the anterior part of the

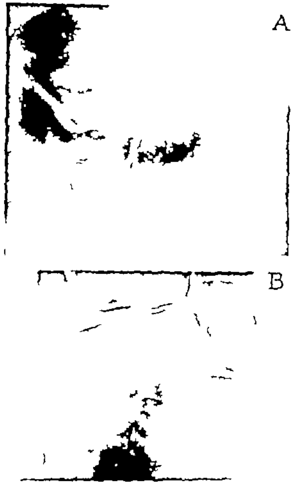


Fig 119 Fracture of the navicular with displacement of fragment A, Lateral view B anteroposterior view

foot with the foot at a right angle or with some plantarflexion This position is fixed by means of a plaster of paris cast which extends from the toes to below the knee Weight bearing may be begun by means of a walking caliper or a heel attached to the cast as soon as the pain has subsided This cast is worn for a period of three to six weeks depending upon the severity of the fracture. After the cast is removed the foot is held in position by raising the

inner side of the heel and the outer side of a transverse bar on the shoe.

DISPLACEMENT OF FRAGMENTS If there is displacement reduction is accomplished under general anesthesia. With the heel held in slight varus extension is applied to the first, second and third meta tarsal bones The anterior part of the foot is plantarflexed increasing the height of the arch and simplifying reduction While this traction is maintained the fragments are molded into position by manual manipulation Traction is continued until a cast has been applied The cast is molded continuously until it has set. This position is checked by roentgenogram and if satisfactory is retained for a period of two to three weeks The cast is then changed a walking caliper applied and weight bearing started This new cast is worn for three weeks or more. If there are signs of structural weakness of the ligaments in the injured area support is obtained by means of waterproof adhesive, this is run from the outer side of the heel over the plantar surface of the foot and then over the area of the navicular bone and attached on the lower leg

If there are multiple fragments and reduction is not possible and if there is interference with motion an open operation is carried out and any loose pieces are removed If the injury is so severe that it is likely to cause joint irritation in the future, or if there is an old fracture with arthritic changes arthrodesis should be done.

Fractures of the navicular bone of the foot in children must be differentiated from Köhler s disease (see Chap 17)

Fractures of the Cuneiform Bones. Fracture of a cuneiform bone is often associated with fracture of a metatarsal bone; it is generally comminuted and there is little displacement. Occasionally there is an associated dislocation Usually such a fracture occurs as the result of a direct injury or of a forcible twisting of the foot in which case it is associated with dislocation at the tarsometatarsal articulation

Treatment Treatment consists in the application of a plaster of paris cast to protect the foot against strain and the development of pes valgoplanus The heel is held in slight varus the anterior part of the foot in slight pronation and with the foot at a right angle, a cast is applied from the toes to just below the knee. Weight bearing is begun as soon as the pain has subsided sufficiently to permit it. Further protection is assured by means of adhesive strapping and felt pads in the shoe

Fractures of the Cuboid Bone. Fracture of the cuboid bone is rare and usually occurs as the result of direct trauma or a crushing injury

the knee. The banjo splint is then attached to the side of the cast. A stainless steel wire is forced through the tip of the toe involved, either through the soft tissue or bone depending on how heavy the traction is to be This wire is formed in a loop resembling a safety pin to prevent compression of the tissues with traction. Traction is then obtained by means of rubber bands The banjo splint is bent so that the pull of the elastic bands is in the axis of the shaft of the involved bone. Traction is continued until satis factory reduction has been obtained and until sufficient callus has formed to permit fixation by means of a plaster of paris cast. This is determined by the roentgenogram The entire period of fixation must be at least six to eight weeks Weight bearing may be begun soon after the cast has been applied.

When the cast has been removed, supportive treatment is essen tial a stiff shanked shoe with a felt arch support should be worn for three to six weeks followed by the gradual use of the corrective shoe to reestablish normal strength in the foot

FRACTURES OF THE TOES

Fractures of the toes usually result from direct trauma They frequently occur when the bare foot strikes against a solid object

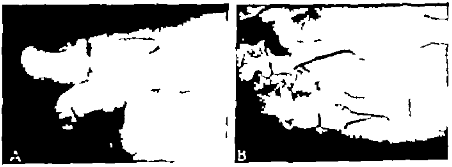


Fig 121 A, Transverse fracture of the proximal phalanx of the great toe. *B* Oblique fracture of the proximal phalanx of the fifth toe

such as a piece of furniture or are the result of a heavy object falling on the toes Fractures of the middle and terminal phalanges of the second and fifth toes rarely give trouble Fractures of the proximal phalanges frequently give rise to an angular dorsal displacement this is most pronounced in the proximal phalanx of the great toe (Fig 121)

Symptoms. The principal symptom is sharp pain in the toe which is usually swollen and tender This pain is increased by motion by pressure of the shoe and by weight bearing Crepitus may fre

If the injury is severe, there will be devitalization of tissue. This devitalized tissue is carefully removed by sharp dissection under anesthesia (débridement). The tendons, nerves and blood vessels of the foot are carefully preserved. If a flap of skin has been turned back, the under surface is cleansed and all devitalized tissue lying underneath carefully removed. Hemorrhage is controlled accurately and all the pulsating vessels are tied. After thorough cleansing, the wound may be closed. Divided tendons should be drawn together and held with fine sutures. When divided nerves are large enough these should also be sutured.

The fracture and dislocation are reduced, and the wound is closed and a cast applied. A window may be cut in the cast over the wound so that the wound can be dressed and observed. Sterile dressings are held in place by a compression bandage consisting of several layers of sheet wadding tied down with a gauze bandage. If no infection occurs the problem is that of a simple fracture. If the wound is infected it may be necessary to remove one or more of the stay sutures to assure satisfactory drainage. At the same time, the foot is elevated and hot applications are made.

The time elapsed between injury and the time the patient is seen by the surgeon determines the method of treatment, that is, whether or not the fracture should be reduced and the wound closed. If the patient is seen within six hours after the injury, surgical cleansing, reduction and closure are advisable; if eighteen hours or more have elapsed, the wound must be treated as infected and should therefore not be closed.

Whether or not to reduce the fracture immediately after thoroughly cleansing the wound in these late cases depends on surgical judgment. The possibility of the reduction of an exposed fragment carrying the infection deeper must be kept in mind.

Emergency Treatment. Emergency treatment of compound fractures of the foot consists, first of all, in covering the wound with a sterile dressing or, if this is not possible, at least with a clean dressing, and in immobilizing the foot either with a pillow splint or blanket splint. If there is arterial bleeding, a tourniquet should be applied. The patient should be taken to a hospital as soon as possible. Antitetanic serum is injected (1500 units subcutaneously); to avoid anaphylaxis a small preliminary dose may be given. The wound is then cleansed and a roentgenogram made.

Treatment of Infected Fractures. When the wound is seen eighteen hours or more after the injury, it is treated as an infected frac

ture. In these cases there is an inflammatory reaction and pus may be present. Under anesthesia the surrounding skin is cleansed while the wound is protected with sterile gauze. The gauze is removed and the wound is gently but thoroughly washed with Emulsept and zephiran chloride or with soap and water, for at least ten minutes. The wound is then examined carefully, and any pus pocket is drained through a small incision. A culture of the material is made, and the appropriate sulfa drug or antibiotic is administered depending on the offending organism. Foreign material is gently removed and exposed devitalized tissue may also be dissected free and removed. The minimum amount of surgery is carried out, and all irritation of tissue should be avoided. Reduction by manipulation should not be attempted.

In an infected fracture of the ankle extension can be carried out by means of a pin through the heel. This, however, is contraindicated if the infection involves the skin around the heel. It is not advisable to apply direct extension if there is no appreciable displacement. On the other hand if the displacement is severe it is conceivable that reduction might be attempted in spite of the infection. With the limb elevated on a Braun frame, the knee flexed and the heel exposed, continuous traction is carried out. Hot moist packs are applied. The traction is continued until the infection has subsided and the wound is closed.

In compound fracture with definite infection in the tarsal area when reduction has not been accomplished it is best to use continuous traction through the metatarsal bones until the infection subsides. If there is no gross displacement a posterior splint can be used while the elevation and hot applications are continued until the infection subsides, after which a cast can be applied.

In compound infected fractures of the metatarsal bones traction can be applied to the toes by means of the banjo splint and the safety pin device described for simple fractures until the infection subsides. When it is impossible to obtain full correction of the fracture a deformity will result. These malunited fractures should not be corrected unless there is a functional disturbance and then not until the infection has cleared up and a period of several weeks to possibly several months has elapsed.

In compound fractures of the toes elevation of the foot and warm moist packs until the infection clears up are usually adequate treatment both for the infection and for the fracture.

If the bone is infected after a compound fracture the situation

is that of an osteomyelitis and the treatment is the same as that for osteomyelitis of the foot In cases in which an abscess forms under the skin adequate drainage should be obtained The most important part of the treatment in these cases is to keep the foot at rest and to assure adequate drainage. When the infection becomes walled off the wound is packed with a petrolatum pack to assure satisfactory drainage without irritation As the inflammatory reaction subsides the direct extension can be replaced by a cast and the petrolatum pack is continued.

Gas Gangrene Infection The possibility of infection by gas bacilli must be kept in mind Early diagnosis of gas gangrene infection is difficult although early recognition is most important for treatment.

The symptoms include a peculiar mousy" smell tenseness a singular copper-colored appearance of the skin and a rapid pulse. The general condition of the patient is usually much worse than the local condition would account for A smear and culture should be made of the pus, and the presence of a short thick bacillus would suggest the possibility of *Clostridium welchii* (*Bacillus perfringens*) infection The presence of gas in the wound should be looked for carefully If there is a large amount of gas, the roentgenogram will show a shadow Palpation of the tissues will reveal a distinctive type of crepitus If there is a small area of gas or air in the tissue, this is released after a period of an hour or so the wound is reexamined and if the area again contains gas a diagnosis must be made of gas gangrene.

In the treatment of gas gangrene all infected and devitalized tissue must be removed and the wound laid wide open at once. The polyvalent antigas-gangrene serum should be utilized soon after the diagnosis is made or is seriously suspected, even though its benefit is not established This is combined with antitetanic serum The exposed tissues are irrigated with hydrogen peroxide. Roentgen therapy may be applied to the area involved Increased oxygen systemically is of benefit, and the oxygen mask should be used. In rare cases the infection spreads so rapidly that surgical measures are futile; severe general toxemia develops and death usually occurs within forty-eight hours

Frequently it is necessary to amputate In these cases the guillotine type of amputation should be done early and should be high enough so as to be absolutely sure to get beyond the involved area However there should be no unnecessary sacrifice of the limb If amputation is begun at a certain level and it is found that there is some gas present the level of amputation should be higher

REFERENCES

Boehler L. The Treatment of Fractures 4th English ed., trans by W Hey Groves Baltimore, Williams & Wilkins Co., 1935

Campbell, W C Malunited Fractures Surg., Gynec. & Obst., 66 466 1938

Dickson F D Fractures of the Ankle Am J Surg., 38 709 1937

Key J A., and Conwell H E The Management of Fractures Dislocations and Sprains 4th ed St. Louis, C V Mosby Company 1946

Magnuson P B Fractures 4th ed Philadelphia, J B Lippincott Company 1942

Speed J S and Smith, H Campbell's Operative Orthopedics 2d ed St Louis, C V Mosby Company 1949

Spiers, H W Comminuted Fractures of the Os Calcis. J.A.M.A., 110 28, 1938

Watson Jones, R. Fractures and Joint Injuries 3rd ed. Baltimore, Williams & Wilkins Company 1943

14

DISLOCATIONS

DISLOCATIONS AT THE TALOCRURAL ARTICULATION

Bimalleolar and posterior lip fractures with a posterior dislocation of the talus have been described A forward dislocation of the talus is rare and is usually associated with a fracture of the anterior lip of the tibia It is brought on as the result of hyperextension of the foot. The head of the talus can be palpated under the skin on the anterior surface of the foot If it is seen soon after the injury reduction can be accomplished easily under general anesthesia The foot *is then held in midposition by a plaster of paris cast* Walking can be begun as soon as the pain and swelling have subsided

Without Fracture. Dislocation at the talocrural articulation without fracture is extremely rare The posterior dislocation occurs more frequently than the anterior Treatment consists in immediate reduction under anesthesia and fixation by means of a plaster of paris cast. Weight bearing is started soon after reduction The cast is worn for three weeks after which heat and massage are utilized to reestablish normal motion

With Fracture. Complete dislocation of the talus is usually associated with fracture, and frequently the fracture is compound It occurs as a result of falling from a height or of a sudden twist of the ankle while running The displacement is usually posterior and lateral The ligament attaching the talus to the tibia and fibula as well as those attaching it to the tarsal bones, is torn The bone is forced out of its socket Swelling is severe and the talus can either be seen protruding through the wound or palpated through the skin Motion at the ankle joint is lost and attempts at movement cause increased pain The relationship of the foot to the tibia is altered either forward or backward depending on the type of dislocation The roentgenogram shows the displaced talus

If it is seen soon after the injury reduction under general anesthesia can be accomplished by means of traction and manual manip-

ulation The knee is flexed to a right angle, and the foot is in plantar flexion to relax the tendo achillis Traction is applied to the calcaneus and the gap is extended so that the talus can be replaced to its normal position

In a compound dislocation the surrounding skin is first washed for at least ten minutes with soap and water The wound is then washed for an equal length of time. Foreign particles and devitalized tissue are removed Under general anesthesia the talus is replaced in its normal position and the wound is closed A cast is applied, with a window over the wound to permit daily dressing and observation When the wound has healed a form-fitting cast may be applied and weight bearing begun

When it is not possible to reduce the talus by traction and manipulation open operation is resorted to With replacement of the bone the wound is closed and immobilization is carried out by means of a plaster of paris cast for a period of two or three weeks after which time the cast is changed A caliper is applied to the new cast and weight bearing is started. This cast is then worn for a period of about six weeks

DISLOCATIONS AT THE TALOCALCANEAL ARTICULATION (SUBASTRAGALOID)

Symptoms. Dislocations at the talocalcaneal articulation are associated with dislocations at the talonavicular articulation They are caused by a fall from a height with the foot plantarflexed (Fig 122)

There is pain, and weight bearing is not possible. The deformity is apparent The calcaneus is displaced and there is projection of the head of the talus on the medial side of the foot. Motion is possible at the talocrural articulation but lateral motion at the talocalcaneal articulation is impossible Any attempt to invert or evert the foot causes increased pain The roentgenogram shows the type of dislocation

Treatment Immediate reduction is obtained under general anesthesia by means of traction and manipulation The knee is held in flexion Traction is applied to the calcaneus with one hand the other hand on the anterior part of the foot pulls it into plantar flexion and extension While an assistant holds the leg the anterior part of the foot is forced laterally and the calcaneus is forced beneath the talus a snap is felt as the reduction is accomplished Fixation is maintained by a plaster cast for four to six weeks After the cast is removed heat and massage are used and motion is gradually reestablished

As an alternative, the original cast may be worn for ten days and then replaced by a form fitting cast with a walking caliper attached. This cast is worn for about six weeks An Unna paste boot is then worn for a period of about ten days and physical therapy is utilized until normal function has been reestablished.

DISLOCATIONS AT THE CALCANEOCUBOID AND TALONAVICULAR ARTICULATIONS

Dislocation or subluxation may occur at the calcaneocuboid and talonavicular articulations, so-called "tarsal" dislocations. These are rare and are usually associated with fractures of the bones of the

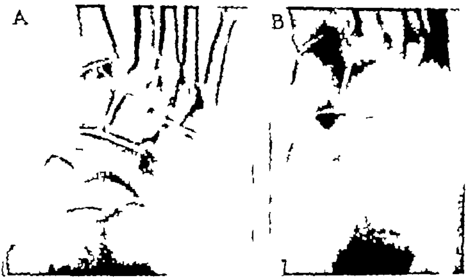


Fig 122 Roentgenogram of dislocation of talocalcaneal and talonavicular articulations *A*, Before reduction *B* after reduction

foot They occur as the result of a sudden injury with the foot in plantarflexion

Symptoms. There is swelling over the tarsal area The foot seems shorter The navicular bone may be displaced anteriorly and felt on the dorsal surface of the foot More frequently the cuboid and navicular bones are displaced downward The type of lesion is revealed in the roentgenogram Movements of the anterior part of the foot are lost and any attempt at motion is painful

Treatment. Treatment consists in reduction under general anesthesia as soon as possible after injury The anterior part of the foot is drawn in extension While the assistant maintains traction the surgeon manipulates and forces the bones back into position In dislocation with fracture it may not be possible to obtain a satisfactory reduction in which case an open operation may be carried

out When satisfactory reduction has been obtained, it is held by a plaster of paris cast, which is kept on for ten days to three weeks, then replaced by a new cast, and weight bearing may be started. This second cast is worn for five or six weeks.

DISLOCATIONS AT THE TARSOMETATARSAL ARTICULATION

Dislocation at the tarsometatarsal articulation may involve one or all of the metatarsal bones the first and fifth being most frequently involved. The displacement may be complete or incomplete and is usually the result of falling from a height or alighting from a moving vehicle.

Symptoms. The symptoms are shortening of the anterior part of the foot swelling on the dorsum of the foot and a projection of the base of the involved metatarsal bone, which can be palpated under the skin Pronation and supination are inhibited, and pain is felt when the injured bone is moved The roentgenogram establishes the diagnosis

Treatment Treatment consists in immediate reduction under anesthesia When all the metatarsal bones are dislocated the heel is held in fixation while traction is applied to the anterior part of the foot. By direct pressure the bones are molded back into their normal positions. If but one metatarsal bone is involved, the traction can be limited to this bone while the replacement is carried out. After reduction has been obtained a form fitting plaster of paris cast is applied directly to the skin Weight bearing can be started as soon as the pain and swelling will permit The cast is worn for three weeks

DISLOCATIONS OF THE TOES

Occasionally a dislocation occurs at a metatarsophalangeal articulation The great toe is most often involved, and frequently it is dislocated as a result of tripping while descending stairs (Fig. 123)

Treatment Reduction is usually carried out easily under general anesthesia Extension is applied to the toe, and the proximal end of the first phalanx is forced downward and into normal position The position is held by means of a cast which is worn for a period of three to four weeks.

DISLOCATIONS AT THE ARTICULATIONS OF THE TOES (INTERPHALANGEAL)

Dislocations of the phalanges of the foot occur as a result of trauma

Treatment. Reduction is usually accomplished easily by direct

traction The position is retained by means of strips of firm-backed, waterproof adhesive tape, run lengthwise on the dorsal and plantar surfaces of the toe, as well as on the sides leaving the tip free. The toe is not encircled so that circulation is not hindered.

SEPARATION OF THE LOWER TIBIAL EPIPHYSIS

Occasionally the lower tribal epiphysis is separated and fractured as the result of a forceful torsion or sudden forceful eversion of the foot.



Fig. 123 Fracture dislocation of the epiphysis of the proximal phalanx of the fifth toe

Treatment Reduction should be carried out as soon after the injury as possible Extension should be applied to the foot while an attempt is made to retrace the movements that caused the displacement of the epiphysis If the epiphysis is markedly displaced and not reduced an open operation must be considered to obtain satisfactory reduction

DISLOCATION BETWEEN THE LOWER ENDS OF THE TIBIA AND FIBULA

A spread of the syndesmosis between the lower ends of the tibia and fibula may occur with fracture of the malleoli or with an ankle sprain The ligaments between the lower ends of the tibia and fibula are torn This is a serious injury that if not properly treated results in a painful disability A displacement between the tibia and fibula

alters the contour of the talocrural articulation in such a way that strains occur and inflammatory reaction is set up, ultimately giving rise to arthritic changes

The spread of the tibiofibular syndesmosis must be kept in mind in every case of serious sprain of the ankle It is the most frequent cause of a persistent, painful ankle after injury Early recognition and treatment are essential.

Symptoms. There is extreme swelling after the injury Weight bearing is painful The roentgenogram shows a gap between the lower ends of the tibia and fibula with an alteration in the contour of the talocrural articulation The displacement between the lower ends of the tibia and fibula may be seen more readily in the roentgenogram with the heel in extreme varus or valgus position since this exaggerates the gap

Treatment Reduction is accomplished by direct extension to the foot and heel. While traction is maintained the tibia and fibula are compressed A plaster of paris cast is applied with the foot in the position of choice. The cast is split anteriorly to allow for increased swelling. The limb is elevated on a Braun splint As soon as the swelling and pain have subsided a new cast is applied The heel and foot are held in extension and the tibia and fibula are compressed. Weight bearing may be begun on about the tenth day The cast is worn for approximately three to four months After removal of the cast, an Unna paste boot is utilized to prevent swelling, more than one boot may be necessary The boot is worn for a period of about three weeks

A shoe that brings the heel into varus and the anterior part of the foot into supination is useful in reestablishing normal function of the foot. Moist heat followed by massage is of aid in decreasing the swelling relaxing muscle spasm and in reestablishing motion

REFERENCES

Conwell H., and Alldredge, R. H Complete Compound Comminuted Fracture Dislocation of the Astragalus. Surgery 1 222, 1937

Kaplan, L. Epiphyseal Injuries in Childhood S Clin North America, 17 1657 1937

Key J A., and Conwell, H E. The Management of Fractures Dislocations, and Sprains. 4th ed St Louis, C V Mosby Company 1946

Penhallow D P Complete Compound Subastragalar Dislocation of Tarsal Bones J Bone & Joint Surg., 19 514 1937

Smith H Subastragalar Dislocations Report of Seven Cases J Bone & Joint Surg., 19 373, 1937

Watson Jones, R. Fractures and Joint Injuries 3rd ed Baltimore, Williams & Wilkins Company 1943

15

SPRAINS

SPRAINS OF THE ANKLE OR LIGAMENTOUS INJURY AT THE TALOCRURAL ARTICULATION

The most common injury to the ankle is sprain or tearing of the soft parts. Ligaments are practically always torn and the capsule and muscles are occasionally involved in the tear. The small vessels are ruptured causing a subcutaneous hemorrhage. If the capsule is injured an effusion into the ankle joint results.

Etiology. The ligaments are torn as the result of a sudden twist of the foot at the ankle joint. An unguarded movement with the foot in inversion or eversion as the body weight is suddenly forced upon the ankle joint will result in a displacement either medial or lateral at the joint with tearing of the ligaments. Such injuries occur frequently in competitive sports. A high percentage occur as the result of a sudden slip or misstep.

Symptoms. The sudden distortion usually results in a sharp pain as the tissues are torn. This is followed by swelling, localized at first over the injured area but gradually increasing until the entire ankle zone is involved. The pain may not be severe at first but the increased swelling is usually accompanied by throbbing and intense pain. Frequently it is possible to walk on the injured ankle immediately after the injury but as the swelling increases weight bearing and movement cause intense pain.

If the lateral ligaments are torn inversion of the foot increases the pain; likewise, if the medial ligaments are involved the pain is increased by eversion of the foot.

Pressure on the injured part elicits tenderness and at night the pain is often intense. The ankle is feverish and local discoloration is noted; this gradually spreads over the foot and up the leg. As the ankle heals the diffuse swelling gradually subsides and the injury may then be definitely localized; the localized swelling however

usually persists for several days In severe sprains the hematoma, which tends to become firm after four or five days, is palpable under the skin

If the injury is extreme, in addition to the tearing of the ligaments themselves a fragment of bone may be torn from the tibia or the calcaneus at the ligamental attachment or the tibia and fibula may be so distorted that the tibiofibular ligament is torn (Fig 124) These injuries can be recognized in the roentgenogram, and such a study should be made of all severe sprains

Treatment Immediate rest is of primary importance. It is often difficult for the injured person to realize the seriousness of the injury



Fig 124 Roentgenogram showing small fragment torn from the talus in a case of sprain.

at once, since the symptoms are relatively slight and he is able to continue with his normal activities. The swelling can be curbed by cold compresses Warm applications are probably of more value, however since the swelling is a normal reaction to the injury; local heat will increase the blood supply and make for more diffuse swelling but will tend to encourage more rapid healing. Considerable relief of pain may be obtained by local vasoconstriction (cold applications) to curb the swelling since some of the throbbing is due to local tension

In severe injuries where hemorrhage occurs a compression bandage is of value This bandage consists in wrapping two rolls of 6-inch sheet wadding from the toes to just below the knee. A 3 inch gauze bandage is then wrapped snugly over this and fastened with the foot in the midposition The position is held and some fixation obtained

by means of adhesive strapping The foot is elevated with one or pillows and weight bearing is prohibited The pain can usi be controlled by means of codeine and aspirin

In less severe injuries a plaster of paris cast may be utilize obtain fixation *If the patient is hospitalized overnight the* are watched to see if there is interference with circulation, an necessary the cast is split If the patient is not under close obse *tion the cast must be split immediately If the cast is not spli* caliper or a heel may be fastened to it the patient is permitte be up and about and weight bearing can be begun at once. If *swelling necessitates an anterior opening of the cast* sufficient wei bearing is possible to enable the patient to return home but el tion of the foot must be carried out for several hours during day to prevent an increase of the swelling

The object of treatment is fixation of the torn structure and turn of normal function as early as possible. As soon as the swell decreases, or at once in the cases of less severe injuries, fixat of the torn ligaments can be obtained by adhesive strapping (I 177) As far as possible, the foot is held in midposition If lateral ligament is torn the heel is brought into valgus sufficier so that it is possible to bring the torn edges into apposition extre valgus should be avoided The bandage is applied and allowed remain for about three weeks. As healing takes place the heel sho gradually be brought into slight varus and the anterior part of foot into pronation The treatment for pes valgoplanus is institu as a prophylactic measure to prevent deformity and the devel ment of a weak foot after the sprain

If the medial ligament is torn a less frequent injury the f is brought into slight varus and the anterior part of the foot i pronation which is the position of choice weight bearing may encouraged at once with this position and normal walking v follow automatically

In many cases both medial and lateral ligaments are torn nec *sitating retention of the midposition or slight varus* either by c or by adhesive strapping If the distortion is so great as to caus spread between the tibia and fibula this must be reduced unc *anesthesia if necessary Correction of the deformity is retained* means of a plaster of paris cast Compression over both malle aids in holding the apposition If in addition to injury to the li ments, *a fragment is torn from either of the malleoli or from* t calcaneal attachment this condition will respond to the treatme described for severe sprains

Heat and massage are useful in injuries in which there has been effusion or extreme swelling The hematoma will absorb more rapidly if diffused. The greater the area of absorption, the more rapidly the swelling will decrease. Prolonged physical therapy after sprains is usually unnecessary if early weight bearing is made possible by means of satisfactory fixation

In some instances the treatment includes the use of a compression bandage followed by the application of a form fitting cast directly to the skin and then an Unna paste boot A Gibney bandage may then be required, after which heat and massage are used and the corrective shoe is worn

CHRONIC SPRAINS OF THE ANKLE

Chronic sprain is a weakened condition of the ligaments in which there is a recurrence of the injury on the slightest provocation It is usually the result of a poorly treated acute sprain There generally is a supination or varus deformity—in other words an elongation of the lateral ligament of the ankle. The looseness of the ankle joint gives rise to a subluxation of the talus This repetition of subluxation at the ankle joint results in an instability

Symptoms. The primary symptom is a sprain, recurring frequently, without much provocation There is slight instability and uncertainty in walking, and the foot is usually weak. As a rule, the muscles are poorly developed

Treatment The treatment of chronic sprains consists in retaining the foot in the corrected position and carrying out functional exercise this is done by means of the corrective shoe to bring about normal gait. In the more severe types where the ligament is stretched, correction may be obtained by surgical intervention This consists in reinforcement and shortening of the lateral ligament and can be done by reflecting a flap of the periosteum from the fibula and attaching it to the tarsal bones In a similar way the tendon of the peroneus brevis or fascia lata may be utilized to reinforce the weakened ligament

Some of the pain is due to spasm of the muscles of the leg, particularly the peroneal muscles This is a reflex spasm due to irritation and the injured ligament is stretched. The spasm tends to keep the ligament under tension and to continue the irritation Injection of the ligament with 1 or 2 per cent procaine brings about relaxation of the muscle spasm and relief of the symptoms (Leriche) The injection may have to be repeated to prevent recurrence of the muscle spasm The injection of procaine in the acute stage re

sults in relaxation of the muscle spasm and permits the foot to be brought into the position of choice. Unprotected weight bearing is not advisable at this stage. The injured structures should be protected until they have had time to heal

REFERENCES

Christopher F Minor Surgery 6th ed Philadelphia, W B Saunders Company 1948.

Kiser J B Procain and Epinephrin Injection in the Treatment of Sprained Ankles. Virginia M Monthly 63 554 1936

Leriche, R., and Fontaine R. De la valeur therapeutique des infiltrations periarticulaires à la novocaine dans les entorses et les arthrites traumatiques Presse med., 40 280 1932.

16

ACUTE BONE ATROPHY (SUDECKS ATROPHY)

Acute bone atrophy is a symptom complex characterized by an osteoporosis which cannot be accounted for by disuse alone. This atrophy occurs as a complication of injury to the foot or ankle. It is associated with pain and stiffness in the foot and with trophic changes in the skin and nails The predominant symptom is pain The peculiar picture seen in the roentgenogram is characteristic.

Etiology The condition is believed to be due to a neurotrophic disturbance. There is a stimulus along the reflex arc which results in a local hyperemia This causes osteoclastic absorption of bone and results in a depletion of mineral salts

Symptoms A relatively minor injury near the ankle or foot may be followed by pain and swelling distal to the site of injury In some instances one is unable to obtain a history of trauma, often one finds the extreme pain and loss of function occurring some weeks after a relatively trivial injury At first there are definite but slight symptoms, then there is an interval during which there is no serious complaint; this is followed by a third stage in which the symptoms become acute. The pain is extreme on weight bearing and prohibits the use of the foot, any attempt at motion causing excruciating pain The pain is relieved while the foot is at rest

The foot becomes swollen and the skin becomes smooth and glossy There is discoloration and the foot takes on a cyanotic color There is an increase in interstitial tension The swelling de creases only after prolonged elevation There is some atrophy of the small muscles of the foot as well as of the ligaments Motion is limited, and there is a tendency toward rapid ankylosis The roent genogram shows a characteristic patchy type of atrophy in the region of and distal to the site of the original injury (Fig 125)

Treatment. The condition does not respond well to local heat

massage or passive motion Unprotected active motion acts as an *irritant, and immobilization usually leads to increased ankylosis.*

In the acute stage it is generally well to allow the pain and swelling to subside before applying a cast The patient is put to bed for six days to three weeks with the limb elevated A sheet wadding compression bandage may be of value during this period.

Fixation that will permit the patient to walk is the treatment of choice. A form fitting plaster of paris cast with a walking caliper



Fig. 125 Roentgenogram in a case of acute bone atrophy of the foot following minor injury at the ankle

or heel attached is most satisfactory This permits walking a short distance and gradually the distance is increased The foot is elevated between the walking periods In view of the extreme pain experienced on weight bearing, it is important to reassure the patient with an explanation of the condition in order to obtain his cooperation The more rapidly function can be reestablished the more rapidly the condition subsides

In extreme cases where the vascular disturbance does not respond, sympathectomy has been performed with good results

The condition is stubborn but will respond to persistent conservative treatment. Usually the symptoms subside long before the roentgenogram shows reestablishment of normal calcium deposit.

REFERENCES

Gurd B Posttraumatic Acute Bone Atrophy Arch Surg., 32:273 1936

Noble, T P., and Hauser, E D W Acute Bone Atrophy Arch Surg., 12 75 1926

Sudeck, P Ueber die acute entzuendliche Knochenatrophie Arch f klin. Chir., 62 147, 1900

17

KÖHLER'S DISEASE OF THE NAVICULAR BONE

Köhler's disease is characterized by a decrease in the size and by a change in the shape of the navicular bone of the foot. It is a self limiting disease the final result of which is complete restoration of

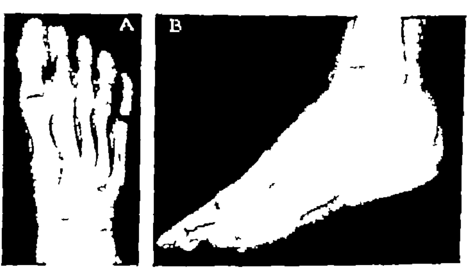


Fig 126 Koehler's disease of the navicular bone Roentgenograms showing characteristic changes of the navicular bone *A* Anteroposterior view *note the irregular distribution of calcium* *B* Lateral view *note the decrease in width and increase in density* (From Hauser Am J Dis Child)

the navicular bone. It usually occurs in children eight to ten years of age; the youngest patient on record was two and a half years old, the oldest ten. It occurs more frequently in boys than in girls (Fig 126).

Etiology The etiology is unknown. It has been pointed out that *the navicular bone which is late in ossifying is subject* to static strain and to repeated trauma. Injuries to the soft bone may bring about

the changes seen in this disease. It has been thought that trauma interferes with the blood supply and sets up nutritional disturbances, the pathologic changes, however are not those of a nutritional necrosis

Symptoms. Usually only one foot is involved although in about 25 per cent of cases bilateral involvement has been described. Limp is the most common symptom The area over the navicular bone is sensitive to pressure. The foot is often weak, and there may be impairment of muscle tone Weight bearing may cause pain in the region of the longitudinal arch At times acute symptoms manifest themselves and there may even be swelling and redness over the navicular area Remissions occur so that the condition may be present without symptoms



Fig. 127 Koehler's disease, healing stage.

The roentgenogram shows the typical changes The navicular bone alone is involved its form is irregular and its density has been increased. It projects above the normal contour of the foot In the dorsoplantar direction its size is greater but from front to back, it is much shorter (Fig 127)

Treatment In the acute phase, when there is pain and swelling,

immobilization with a plaster of paris cast for a period of three to six weeks is advised In most cases the symptoms are relatively trivial and subside with relief of the strain on the longitudinal arch. This can be accomplished by throwing the weight on the outside of the foot by means of the corrective shoe. The heel of the shoe is raised on the inner side to obtain varus, and the comma-shaped transverse bar is raised on the outer side to assure pronation of the anterior part of the foot In this way the longitudinal arch is raised and the strain at the navicular area is relieved

With reestablishment of normal gait the symptoms are relieved, the foot becomes stronger and the structure of the navicular bone is gradually reestablished. After a period of one to three years the size, contour, architecture and calcium content of the navicular bone are completely restored

REFERENCES

Hauser E D W Koehler's Disease. Am J Dis Child, 3 126 1929

Karp M G Koehler's Disease of the Tarsal Scaphoid J Bone & Joint Surg 19 84 1937

Koehler A. Typical Disease of the Second Metatarso-Phalangeal Joint Am. J Roentgenol., 10 705 1923

18

FREIBERG'S DISEASE OR KOHLER II

Freiberg's disease is characterized by an enlargement of the heads of the second and third metatarsal bones and, rarely, of the fourth. Usually only one bone is affected at a time.

Etiology The condition is believed to be the result of mechanical strain and abnormal repeated traumas that occur at the heads of the second and third metatarsal bones It is usually seen in cases of pes valgoplanus associated with metatarus latus

Since the second metatarsal bone is generally the longest, it is exposed to increased weight bearing and trauma Cases have been described in which the condition developed after the radical operation for hallux valgus When radical operation was performed and the weight bearing surface of the first metatarsal bone was lost, increased strain was placed on the head of the second

Acute symptoms are sometimes brought on as the result of direct trauma or sudden strain as in jumping. The alteration of the head of the metatarsal bone is believed to be secondary to the increased demand on it.

Symptoms. Pain is usually present on weight bearing, particularly in walking There is tenderness and swelling over the dorsal area In the acute phase, pain may persist while the foot is at rest. Movement of the toes is limited There is a tendency toward dorsiflexion and contraction Attempts to flex the toes in a plantar direction with passive motion cause severe pain An inflammation occurs at the metatarsophalangeal articulation with contracture of the collateral ligaments At times the enlarged head of the involved metatarsal bone is palpable.

In the early stages little change is seen in the roentgenogram There may be a slight decrease in the calcium deposit of the head of the affected metatarsal bone Gradually its shape alters The convex articular surface becomes flattened and the articular space appears wider The head may show a fragmentation stage associated with a

loose fragment at the articular space The dorsal part of the head seems to be involved to a greater degree than the plantar part.

In the later stages the decalcification is replaced by an increased calcium deposit, and there may be an overgrowth or projection of callus in the dorsal area of the head of the metatarsal bone. A deformity of the head usually persists and secondary arthritis may develop (Fig 128)

Treatment Treatment consists first in relieving weight bearing on the heads of the second and third metatarsal bones Early recognition is important to prevent the development of advanced osseous changes During the acute phase elevation and hot packs, with gentle massage, are beneficial in relieving the symptoms. A



Fig. 128 Freiberg s disease (Koehler II) of the second metatarsal bone Note the deformity of the head and the secondary arthritis

heavy soled shoe may be padded in the region of the longitudinal arch with a second pad immediately proximal to the heads of the second third and fourth metatarsal bones This latter pad removes the pressure from the involved head The rolling gait should be discouraged and the patient should walk with the foot slightly rotated externally to prevent stretch at the metatarsophalangeal articulation

After the inflammation at the metatarsophalangeal articulation has subsided, the corrective shoe is prescribed to correct the pes valgoplanus and at the same time, to relieve the excessive weight bearing on the heads of the second and third metatarsal bones In carrying out normal gait with the corrective shoe the transverse bar tends to force the toes in a plantar direction stretch the collateral ligaments and correct the dorsal contracture The corrective force should be applied gradually otherwise forceful stretching of the ligaments will cause pain and may even set up irritation

For this reason it is advised that the shoe be worn at first for short periods of but five to ten minutes at a time Gradually, as the ligaments are stretched and the patient can bring the foot into more normal position, he is able to tolerate the correction for a longer time, and the duration of the exercise period may be lengthened accordingly Ultimately all symptoms are relieved by wearing the corrective shoe It is usually continued thereafter because it is most comfortable.

In most cases the conservative treatment just described has made operative procedures unnecessary However in advanced cases with marked alteration of the head of the metatarsal bone and loose bodies in the joint, correction by operation has been suggested Through a small dorsal incision the loose bodies are removed and the rough irregular head is made smooth by means of a small curved chisel Removal of the head of the metatarsal bone is not advised, since this increases the strain on the heads of the others

REFERENCES

Freiberg, A. H Infraction of the Second Metatarsal Bone. Surg., Gynec. and Obst., 19 191 1914 The So-called Infraction of the Second Metatarsal Bone. J Bone & Joint Surg., 8 257 1926

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MARCH FOOT

(Deutschlaender's Disease Pied Forcé)

March foot is a linear fracture through the middle of the shaft of a metatarsal bone appearing without the history of a severe injury It may occur in the second or third metatarsal bones The condition derived its name from the fact that it was first noted in army recruits after prolonged marching. Clinically it is characterized by swelling of the soft tissue in the dorsal area with pain and tenderness over the involved bone

Etiology The condition is usually associated with metatarsus latus and pes valgoplanus and is sometimes secondary to the radical operation for hallux valgus It is believed to be caused by a mechanical insufficiency in the anterior part of the foot which results in an increased load on the metatarsal bone In addition it may be the result of a strain and may occur in civilians as well as in military recruits.

Murk Jansen noted spasm of the interossei muscles and expressed the opinion that it led to vascular obstruction which involved the bone as well as the soft tissue This interference with circulation was conducive, in his opinion to atrophy of the bone which ultimately resulted in fracture

Symptoms. The patient complains of pain in the region of the *second or third metatarsal bone He favors the affected foot* and walks with a limp There is a palpable edematous swelling on the dorsum of the foot Tenderness is present over the shaft usually at *the junction of the middle and distal thirds of the painful metatarsal* bone The patient sometimes complains of cramps in the small muscles of the anterior part of the foot

In the early stages the roentgenogram may show no change After about ten days periosteal changes are seen After four weeks the roentgenogram reveals a linear fracture Subperiosteal hemorrhages are said to occur The periosteal callus is excessive *and palpable* and indicates that the condition has been present for some time a period

of about five weeks (Fig 129) As healing advances the callus gradually decreases

Treatment. Swelling, tenderness and muscle spasm in the region of the involved metatarsal bone have been observed without fracture or callus This is probably the prodromal stage Treatment by means of the corrective shoe, as described under Pes Valgoplanus has resulted in cure with the development of but minor changes as seen in the roentgenogram The corrective shoe is sometimes too strenuous, in which case the strain on the metatarsal bone may be relieved by adhesive strapping to correct the metatarsus latus This consists

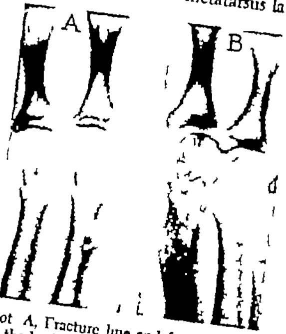


Fig. 129 March foot *A*, Fracture line and formation of callus *B* swelling as the result of the healing, in a similar fracture on the other foot.

in drawing the first and fifth metatarsal bones in a plantar direction by means of adhesive strapping One strip of adhesive is started on the dorsal side of the first and another on the dorsal side of the fifth metatarsal bone The bandages are drawn downward and obliquely over the sole and then over the ankle up to the leg The effect of the adhesive so applied is to reestablish the transverse arch

In the acute stage when there is pain swelling and limp or when the roentgenogram shows a fracture line the foot should be kept at rest Elevation and hot packs with light massage are valuable during the period of swelling Protection with a plaster of paris cast may be necessary for three to four weeks Usually however adequate protection may be obtained by a firm arch support which is raised higher under the fractured bone

Treatment must always include removal of the underlying cause, which is strain of the anterior part of the foot. Metatarsus latus and pes valgoplanus are treated by means of the corrective shoe The transverse bar corrects the spread of the anterior part of the foot and raises the middle metatarsal bones so that the strain of weight bearing is decreased on the heads of these three bones While this treatment is being carried out heat and massage can be utilized to advantage to decrease the muscle spasm in this area and to improve the circulation

The symptoms are relieved by these corrective measures and normal function is gradually reestablished in the foot The fracture heals with callus but the callus gradually decreases so that the bone ultimately assumes a normal contour

REFERENCES

Bernstein, A., and Stone, J B March Fracture—A Report of 307 Cases and a New Method of Treatment J Bone & Joint Surg., 26 743 1944
Jansen, M March Foot J Bone & Joint Surg., 8 262, 1926
Speed, J S., and Blake, T H March Foot J Bone & Joint Surg., 15 372, 1933

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TENDON RUPTURE AND DISLOCATION

RUPTURE OF THE GASTROCNEMIUS MUSCLE

This condition usually occurs in athletes particularly tennis players sprinters, hurdlers and ball players It may, however occur spontaneously with slight or even no exertion

Symptoms The most important symptom is a sharp pain in the calf which comes on after sudden exertion This is followed by severe muscle spasm Depending on the severity of the injury the calf may show swelling hematoma with discoloration and persistence of the spasm. The tear may be so great that a gap is palpable between the muscle fibers. The retraction of the proximal muscle belly leaves a gap in which a finger can be placed Relatively few strands or muscle fibers may be torn and the result is a sharp pain without objective findings except the muscle spasm which subsides after a few minutes Occasionally with sudden forceful exertion of the posterior group of muscles an acute pain is suddenly felt in the calf. There is loss of power and a feeling that something has snapped. This condition was believed to be due to a tearing of the plantaris muscle but it is more likely due to a tearing of the fibers of the soleus or gastrocnemius muscles

Sudden exertion should be avoided when there is increased danger of tearing fibers—for instance if a limb has been kept in a cast and the muscle fibers have become weakened.

Treatment. In complete tear of the gastrocnemius muscle it is best to expose it and suture the fibers in order to assure the reestablishment of normal strength In a partial tear the foot should be held in plantarflexion with the knee flexed In this way relaxation of the muscle is obtained The limb is kept quiet until the muscle has healed, a matter of two to three weeks In some cases it may be necessary to discontinue all weight bearing in others, strapping of the foot and ankle, holding the plantarflexion with a raise of the heel may be

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sufficient treatment. In any case, sufficient time should be allowed for the muscle fibers to heal completely before they are subjected to strain otherwise, they may remain weak.

RUPTURE OF THE TENDO ACHILLIS

The tendo achillis may rupture as the result of a violent contracture. This usually occurs at the junction of the muscle belly and the tendon. The tendon may be torn from its insertion into the calcaneus



Fig 150 Calcareous deposits in the tendo achillis.

or a short distance above it. Cases have been reported in which there was spontaneous rupture. The torn ends become attached to the tibia in the process of healing.

Symptoms. The first symptom of traumatic rupture is a *feeling of something having given way*; a sudden snap may be associated with sharp pain. Pain is localized over the area of rupture, and there is tenderness, swelling and discoloration. A gap can be felt between the tendon ends. There is loss of power, but the foot can be voluntarily brought into plantarflexion by virtue of the unimpaired posterior tibial, peroneal and plantaris muscles.

Treatment If rupture of the tendon is recognized at once, exposure and repair will give excellent results If the condition is unrecognized however, and scar tissue forms in the gap, satisfactory repair by operation is much more difficult.

In incomplete tear at the junction of the muscle and the tendon conservative treatment may give satisfactory results This consists in fixation of the ankle in plantarflexion with the heel elevated and the knee flexed If the tear in this region is complete or so severe that there is definite weakness or if there is a gap early surgical repair is indicated

In severe cases when treatment has not been carried out, or in cases of spontaneous rupture, there may be a disability which requires surgical repair The tendon is exposed, the scar removed the vicarious attachments are released and the tendon is repaired with chromic catgut The plantaris tendon may be used as a suture to close the gap in the injured tendo achillis

Myositis Ossificans of the Tendo Achillis. The tendo achillis occasionally shows calcareous deposits which may give rise to symptoms of discomfort This is a relatively rare occurrence and usually does not require any treatment (Fig 130)

TRAUMATIC DIVISION OF THE TENDO ACHILLIS

Traumatic division of the tendo achillis is usually the result of an accident and most frequently occurs among sheet metal workers Striking the back of the leg against the sharp margins of scraps of sheet metal may result in an incision of the skin and tendon

Treatment Treatment consists in washing the wound with soap and water for ten minutes suturing the tendon and closing the wound The tendon is fixed in a relaxed position by holding the foot in plantarflexion the knee being flexed by means of a plaster of paris cast or a splint Although the tendon usually heals with some scar tissue, the prognosis for recovery is satisfactory, the power of healing of the tendo achillis being extraordinarily good For this reason simple closure of the tendon sheath followed by fixation with the tendon relaxed will result in healing and the reestablishment of normal function

RECURRENT DISLOCATION OF THE PERONEAL TENDONS

The course of the peroneal tendons from the leg to the foot runs at a right angle in the region of the ankle joint They are held in position by the superior retinaculum which prevents them from slipping anterior to the fibula In severe injury the fibers of the retinaculum

do not tear but its attachment is torn free from the fibula thus permitting anterior displacement of the peroneal tendons

The condition is usually the result of trauma occurring in competitive sports in which the foot is brought into extreme adduction with a sharp varus twist at the ankle and a consequent sharp contraction of the peroneal muscles to prevent the accident

Symptoms. There is sudden displacement of the peroneal tendons anteriorly whenever the foot is actively everted.

Treatment. If the patient is seen immediately after injury conservative treatment is the treatment of choice. The foot is fixed in the midposition or with the heel in slight valgus by means of a plaster of paris cast applied directly to the skin The cast extends from the toes to the knee and is accurately molded particularly in the region of the lateral malleolus In case of a minor tear fixation may be held with adhesive tape.

If the retinaculum has not been permitted to heal and if the dislocations recur surgical intervention is necessary under general anesthesia and with a bloodless field a curved incision is made around the lateral malleolus The peroneal tendons are then exposed and replaced in their normal grooves Through the same incision the lateral margin of the tendo achillis is exposed, and a section is split from its lateral side, allowing an attachment to remain at the lower end. The free end of the attached slip is then placed in front of the peroneal tendons drawn through a hole drilled in the fibula and brought around anteriorly to be sutured upon itself Thus a firm loop is made to hold the tendons in place A piece of fascia lata may be utilized to make a new retinaculum to hold the peroneal tendons in place

This condition is nearly always associated with extreme valgus. Since displacement is more liable to occur in this position, bringing the heel into varus may decrease the frequency of its occurrence.

REFERENCES

Bickel, W H., and Moe, J H Translocation of the Peroneus Longus Tendon for Paralytic Calcaneus Deformity of The Foot Surg., Gynec. & Obst., *78* 627 1944

Gilcreest E L. Ruptures and Tears of Muscles and Tendons of the Lower Extremity J.A.M.A., *100* 153 1933

Jones, E Operative Treatment of Chronic Dislocation of the Peroneal Tendons J Bone & Joint Surg., *14* 574 1932.

Steinder A. Orthopedic Operations Springfield Ill Charles C Thomas, 1940

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DISEASES OF THE NERVES

TRAUMATIC DIVISION OF NERVES THAT SUPPLY THE FOOT

Division of or injury to the sciatic nerve or its branches, either the tibial or peroneal nerves will give rise to disorders in the foot.

Etiology The nerve may be partially or completely divided, or there may be complete or incomplete physiologic interruption When there is actual anatomic division, the nerve fibers are severed, when there is physiologic interruption only the power of conducting impulses is lost. In physiologic interruption, therefore, spontaneous recovery may occur; in anatomic division the injury must be repaired.

Actual division may be the result of a cut or bullet wound The nerve may be injured as the result of pressure; the peroneal nerve is exposed to pressure from a splint that is too tight, a brace strap that binds or a tight cast Severe fractures may actually tear the nerve, or newly formed callus may exert pressure on the nerve. The nerve may likewise be injured by overstretching, as in manipulative correction of an old flexion deformity of the knee it may, on the other hand be caught in scar tissue which constricts the nerve fibers and causes paralysis

If a nerve is divided and the ends are not in contact new fibers grow from the proximal part and coil up to form a neuroma To obtain growth in the distal section of the nerve it is necessary to resect this bulbous end and bring the two segments together

Symptoms. If the sciatic nerve is injured the symptoms will be those of injury to either the tibial or common peroneal nerves, or both If the injury is high in the popliteal space, both the common peroneal and tibial nerves will be involved below the popliteal space where the sciatic branches are separated either nerve may be involved alone.

With a peroneal nerve injury sensibility is lost over the dorsal surface of the foot and the anterior and lateral surfaces of the leg. In the most central part of the involved area pressure pin prick

and temperature sensations are absent, sensation to light touch is lost over a larger area If there is a partial lesion, several of the muscles may be active, whereas others are paralyzed and only part of the area supplied by the sensory nerve would be involved. The borders of the area supplied by the paralyzed nerve are sensitive to pin prick and to extreme temperatures The muscles supplied by the common peroneal nerve are paralyzed the dorsiflexors of the foot including the extensors of the toes and the peroneal group Paralysis of these muscles results in plantarflexion or equinus deformity of the foot with a plantarflexion contracture of the toes and a slight tendency toward inversion due to the action of the tibialis posterior The foot cannot be brought into dorsiflexion nor can the proximal phalanx of the toes be dorsiflexed, and the ability to evert the foot is lost The patient walks with the drop foot gait. There is some tendency toward trophic disturbances the skin is dry shiny and cold and the nails may lose their gloss and show ridges.

With a tibial nerve injury there is a sensory disturbance of the skin on the sole. When the tibial nerve is divided the muscles paralyzed are the inverters and plantarflexors of the foot. The plantar flexor muscles of the foot supplied by the tibial nerve are the gastrocnemius and soleus Owing to the paralysis of the plantarflexors there will be a tendency toward talipes calcaneus. The tibialis posterior which is a strong inverter of the foot, is also supplied by this nerve As a result of the paralysis of the posterior tibial muscle, the heel will go into valgus The power to flex and separate the toes is lost since the long and short plantarflexors of the toes as well as the lumbrical muscles and the abductor hallucis are all supplied by the tibial nerve. Trophic disturbances may occur and result in ulcers particularly if unequal pressure is exerted on the foot The muscular atrophy is rapid and extensive, and the electrical test shows the presence of the reaction of degeneration

Treatment. In traumatic division of the nerve the wound is explored and the nerve sutured unless infection is present. If the nerve is caught in a scar it is dissected free, the scar tissue is removed and the nerve may be transplanted. When the nerve is injured as the result of a fracture it may undergo spontaneous recovery if it is caught in a callus however the paralysis usually becomes progressively worse In this case the callus is exposed at the site of fracture and the nerve is freed It is sometimes necessary to transplant the nerve to prevent its being caught in the formation of new callus

When a large gap results from destruction and retraction of the nerve, a nerve transplant may be considered. After suture of the in

jured nerve, or in case spontaneous recovery is expected, the paralyzed limb is splinted to relieve tension on the nerve and to prevent contracture of the active muscles. The first sign of recovery usually begins at the proximal part of the limb and spreads toward the periphery. This may be noted as early as six weeks after injury or operation; it may take up to two years to obtain the maximum recovery.

During the period of recovery, muscle tone and circulation are maintained by means of moist heat and light massage; physical therapy may be begun three or four weeks after the operation. Extreme care must be taken in the application of heat not to cause a burn. A single lamp in a cradle, which will create a temperature of about 99° F., is usually sufficient.

With a complete or even partial lesion of the tibial nerve, when there is anesthesia of the sole and poor trophic supply, the danger of trophic ulcer is great. Care must be taken to prevent pressure, as pressure from a splint or plaster can result in a trophic ulcer within thirty-six hours. A rough point in a shoe, or even wrinkles in hose, may result in a blister and an ulcer difficult to heal. The ulcer may become deep and reach the tendon sheath. Infection is a serious complication, owing to the poor blood supply.

The foot must be held in the position of choice, by means of a light, form-fitting splint made of plaster of paris, plastic material, or metal. Rest in bed is not necessary during the entire period of recovery. Adequate protection of the paralyzed muscles can be obtained on weight bearing by a plaster of paris cast with a walking caliper attached.

Ambulant treatment is recommended, since it improves the circulation, strengthens muscles that are not paralyzed, and permits the paralyzed ones to resume their function as they recover.

In sciatic involvement the knee as well as the foot is included in the cast. The form-fitting cast can be replaced by a leather and steel brace with an ankle catch to prevent the foot from dropping. The brace is attached to a metal foot plate, which will help support the weakened foot.

In a peroneal nerve lesion the brace is used to prevent foot drop and any tendency toward inversion of the foot. A single outside iron with an ankle catch and spring to prevent the foot drop is used.

In a tibial nerve lesion, when the foot tends to go into dorsiflexion and valgus, a foot plate and bilateral iron is used to hold the foot in position.

In cases of irreparable injury to the sciatic nerve the maximum amount of function is restored by means of arthrodesis, including

fusion of the talocalcaneal talonavicular and calcaneocuboid articulations which stabilizes the foot To prevent foot drop posterior bone block is the most effective type of operation In cases of irreparable injury to the peroneal nerve where there is no deformity the same surgical procedure is indicated If a deformity is present manipulative correction must precede surgery

METATARSALGIA

(*Morton s Disease*)

Metatarsalgia is a painful condition which is usually in the region of the head of the fourth metatarsal bone but is sometimes localized

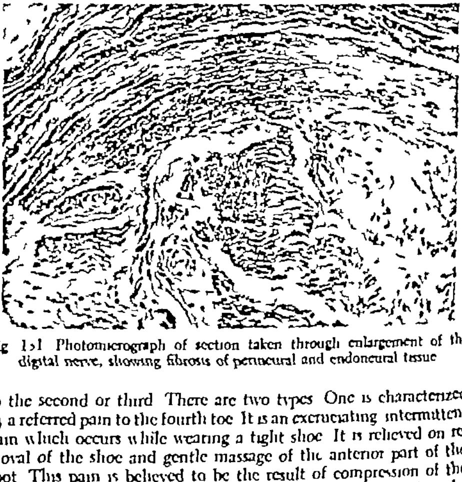


Fig 151 Photomicrograph of section taken through enlargement of the digital nerve, showing fibrosis of perineural and endoneural tissue

to the second or third There are two types One is characterized by a referred pain to the fourth toe It is an excruciating intermittent pain which occurs while wearing a tight shoe It is relieved on removal of the shoe and gentle massage of the anterior part of the foot This pain is believed to be the result of compression of the interdigital nerve The other type of metatarsalgia is limited to the metatarsophalangeal articulation of the fourth or second or third toe. There is usually a contracture of the capsule and collateral ligaments with a dorsiflexion deformity of the proximal phalanx and

a tendency toward claw toe The plantar surface of the head of the metatarsal bone involved is painful and tender, and there is an inflammatory reaction in this area Usually a plantar callus denotes excessive pressure over the head of the metatarsal bone.

Etiology In those cases in which the pain is in the toe, displacement of the head of the metatarsal bone is the causative factor It leads to a neuritis in which the interdigital nerve is compressed between the displaced heads of the metatarsal bones (Fig 131) Originally an inflammatory process occurs in the interdigital space, involving the perineural tissue Sometimes an adventitious bursa is formed Later this inflammation may result in varying degrees of degenerative change, from persistent mild inflammation to advanced degenerative change. With increase in fibrosis and the deposition of hyalin and collagenous material an enlargement of the interdigital nerve at its bifurcation occurs In some cases the head of the metatarsal presses upon the interdigital nerve from above If the head of the metatarsal is displaced in a plantar direction there is a spread of the anterior part of the foot and loss of the arch, or there may even be a plantar convexity instead of an arch An additional factor is a tight shoe which forces the heads of the metatarsal bones against each other thus causing compression of the nerve. Occasionally an overgrowth of bone in this region will cause compression of the nerve. The high heeled shoe is also a factor inasmuch as it throws undue strain upon the anterior part of the foot. Pes valgoplanus and foot strain are usually associated with this condition

In those cases in which the metatarsalgia is limited to the head of the metatarsophalangeal articulation, there is a definite sign of the abnormal pressure The stress of the body weight results in an inflammation on the plantar surface of the head of the metatarsal bone as well as at the metatarsophalangeal articulation Metatarsus latus and pes valgoplanus may be the underlying causes of this type of metatarsalgia It is also seen secondary to chronic infectious arthritis of the foot The abnormal position of the foot results in an alteration in weight bearing and causes abnormal pressure upon the head of the metatarsal bone

Symptoms. The metatarsalgia characterized by a referred pain in the toe is often preceded by a feeling of subluxation of the head of the metatarsal bone. It usually occurs while walking in high heeled shoes and is relieved by removing the shoe and rubbing the toes or by massaging the heads of the metatarsals The attack of pain is sometimes followed by a feeling of numbness or tightness in the toe. The condition is more frequently unilateral when it is bilateral

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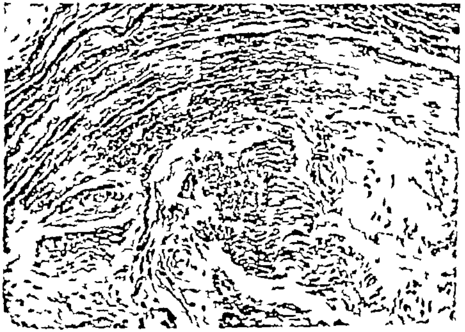


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usually one foot is more severely involved than the other The anterior part of the foot may be loose, and the head of the metatarsal bone can readily be displaced in a plantar direction With the head of the metatarsal bone in this position compression of the anterior part of the foot may reproduce the acute pain in the toe. This pain is intermittent and between attacks the patient may be symptom free Sometimes there is a constant pain in the region of the metatarsophalangeal articulation and head of the metatarsal bone

Pain which is limited to the metatarsophalangeal articulation and head of the metatarsal bone is burning and cramping The objective findings include a plantar callus under the head of the metatarsal. There is tenderness over the plantar surface and dorsiflexion contracture at the articulation There may also be a depression on the dorsum over the head of the metatarsal bone All the toes are contracted forming a moderate degree of claw toe The anterior part of the foot is in supination so that if the heel were placed in normal position the head of the first metatarsal bone would not touch the ground There is some limitation of motion in the tarsal area

Treatment Treatment consists first in removing the irritation from the affected interdigital nerve This can be accomplished by placing a felt pad just proximal to the heads of the metatarsal bones, with the inclined plane directed medially to reestablish their normal positions Repeated injections of 2 to 5 cc of 2 per cent procaine solution between the heads of the third and fourth metatarsal bones, or over the point of greatest tenderness will give immediate symptomatic relief and aid in the resolution of the inflammatory process. The skin is punctured and the procaine solution injected while the needle is being inserted to its full depth When the pain is very acute, this can be repeated daily until control of the pain is obtained. In most instances however injections at weekly intervals have been found satisfactory Frequently one injection gives immediate and permanent relief provided corrective treatment is carried out When it takes longer to obtain correction the injections must be repeated, and in these patients weekly intervals are best

When the irritation has been present for a long time an enlargement of the digital nerve at its bifurcation results Betts described this as a neuroma and advised surgical removal McElvenny called it a neurofibroma and also advised surgery When the pain is persistent and does not respond to conservative treatment surgical removal should be carried out A transverse bar applied to the outside of the sole of the shoe will bring about the same effect In the most

acute phases of metatarsalgia, and when the condition has been of long standing, rest in bed, elevation of the foot and the application of warm moist packs may be necessary to relieve the acute symptoms A metal arch support shaped to fit the arch and with an anterior raise behind the heads of the metatarsal bones, is of benefit Strapping the anterior part of the foot so that the heads of the middle metatarsals are higher than the first and fifth decreases the pain

In order to obtain a cure, it is necessary not only to get symptomatic relief but also to eliminate the causative factor, namely, the altered weight bearing of the foot In the street and dress shoes worn by the patient the anterior felt pad is in the shape of an inclined plane and is placed posterior to the head of the fourth metatarsal bone, with the incline directly medially whereas the felt pad in the region of the longitudinal arch is directed laterally to hold the heel in the varus position Later, the corrective shoe is used The comma shaped transverse bar has an inclined plane in the medial direction, and the heel is brought into varus This treatment is identical with that directed against pes valgoplanus, particularly when the anterior part of the foot is in supination It restores not only the longitudinal arch but also the transverse arch and relieves the compression at the heads of the metatarsal bones Symptomatic relief is obtained and the causative factors are eliminated.

When the heel of the shoe generally worn is obviously too high and has too small a weight bearing surface and when the anterior part of the shoe is too narrow the shoe must be discarded If the tendo achillis is short as from wearing high-heeled shoes, it must be stretched This can be done gradually with low heeled shoes or by a plaster of paris cast. Tendon lengthening may sometimes be necessary

If changes in the nerve are so advanced that relief is not obtained by eliminating altered weight bearing, surgery is indicated A small dorsal incision is made in the web between the involved toes, and the entire enlarged part of the digital nerve, including its bifurcation is excised

CAUSALGIA

Causalgia is a peculiar post traumatic symptom complex which frequently follows bullet wounds It is relatively rare, however, and usually comes only to the attention of the neurologist or army surgeon

Symptoms. Characteristic of causalgia is a sensation of burning

usually continuous with paroxysmal exacerbations Pain is experienced in the ball of the foot associated with a feeling of dryness of the skin This is increased by irritation and by sudden movement or jarring Touching a dry object, or even the thought of dryness, increases the burning

A definite emotional and nervous disturbance is associated with the condition Nervous shock of any type will increase the sensation of burning The pain is not limited to the nerve supply of the injured nerve but has a more diffuse distribution In causalgia the lesion will usually be found to be a partial one, incomplete anatomically or partially invaded by surrounding scar tissue. It is found more commonly in the median and peroneal than in other nerves

Once the symptoms of causalgia are present they may be continued or increased in severity by an increase in afferent impulses (Fig 39 p 72) The area of injury is the first and most frequent site for the origin of these impulses Owing to the injury, fiber inter action or cross-talk excites pain fibers directly These impulses may stimulate the anterior horn cells of the same segment, causing muscle spasm which excites pain receptors that are the second source of more pain stimuli The preganglionic sympathetic neurone may also be stimulated, causing vasomotor alterations which will be the third source of additional painful stimuli. Cutaneous hyperalgesia may develop The increased sensitivity of the pain receptors is a fourth source. With the constant bombardment of the internuncial neurones in the gray matter of the spinal cord from these peripheral stimuli, and increased cerebral excitation an internuncial pool is formed This acts as the fifth source of increased impulse activity These multiple foci of increased pain stimuli form a vicious cycle

Treatment. Treatment consists in rest with the foot in a splint. Passive motion should not be attempted. Elevation and the application of moist packs offer some relief The disturbance as has been indicated seems to be connected with the autonomic nervous system it has therefore been suggested that sympathectomy might be of some value General hygienic measures and the use of vitamins B_1 and B_2 are of some value in combating the nerve fatigue. The disorder usually reaches its height about four to five months after the injury and then gradually clears up spontaneously although slowly Sedatives may be necessary to control the pain during the height of the attack.

It is often treated successfully either by neurolysis or by resection

of the area of the lesion, if this can be determined, and by suture of the freshened nerve ends

NEURITIS OF AN ISOLATED DIGITAL NERVE

A peculiar vasomotor disturbance involving the fifth toe is occasionally seen The etiology is probably a compression of the toe resulting in irritation of the digital nerve Mycosis is an associated finding.

The onset is characterized by acute sharp burning pain which occurs periodically either with weight bearing or at rest The pain is aggravated by cold damp weather

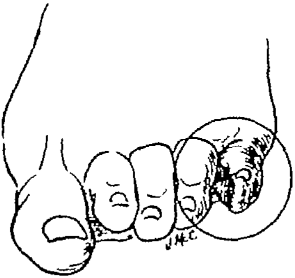


Fig. 132. Neuritis of small toe, showing typical ridging and discoloration

Clinically there is a tender sharp ridge along the dorsomedial surface of the toe (Fig 132) The entire toe is erythematous

Treatment Relief can be obtained by injecting procaine at the base of the toe In some cases a single injection is sufficient, but usually a half dozen are necessary Pressure is relieved by padding with lamb s wool between the toes and wearing a sufficiently wide shoe The foot is treated for mycosis If the symptoms persist, excision of a part of the nerve to the toe may be required

NEURITIS OF AN ISOLATED SENSORY NERVE IN THE FOOT

Neuritis of an isolated sensory nerve in the foot is a rare condition There is a chronic inflammation of the perineurium without involvement of the nerve fibers The superficial peroneal nerve or

the distal end of the saphenous nerve may be involved with this condition The disturbance is almost always associated with foot strain and pes valgoplanus

Symptoms. When the superficial peroneal nerve is involved there is a burning and tingling pain over the lateral side of the foot The most common symptom however is numbness due to decreased sensibility There is a decrease in the sensitivity of the skin both to touch and temperature The sensation of pain and burning usually comes on after prolonged standing If the saphenous nerve is involved symptoms are experienced over the medial side of the leg and the inner side of the foot and ankle Pressure on the nerve elicits pain and the thickened nerve may be palpated.

Treatment. When the foot strain is relieved and the pes valgoplanus deformity corrected the nerve symptoms subside. In some cases there is apparently spontaneous recovery A few cases have been reported in which exposure of the nerve and resection of a segment was followed by relief of symptoms

This condition is similar to meralgia paresthetica which involves the lateral cutaneous nerve.

PLANTAR NEURITIS

Medial and Lateral Plantar Nerves. Inflammation of the medial and lateral plantar nerves of the foot is sometimes observed secondary to injury of the posterior tibial nerve. It is also seen in cases of extreme pes valgoplanus In the latter type of case the nerve has supposedly been stretched as a result of the valgus position of the heel or in extreme pes valgoplanus by the elongation and lowering of the longitudinal arch

Symptoms There is tenderness over the plantar surface of the foot and pressure on the nerve below the medial malleolus causes pain There is likewise atrophy of the small muscles of the foot and the toes assume a dorsiflexed position

Treatment Treatment consists in keeping the foot at rest until the irritation of the nerve subsides This is followed by correction of the pes valgoplanus

Tibial and Peroneal Nerves. Another form of plantar neuritis involves the tibial nerve, and sometimes the peroneal nerve below the malleoli, with a localized inflammatory lesion A ganglion may be present which includes the nerve and causes a true neuritis. The condition has been observed following twisting of the ankle The cause is believed to be an inflammatory change around the nerve after hematoma

Symptoms When the tibial nerve is involved, there is an increased sensitivity over the plantar surface of the foot The nerve can be palpated below the medial malleolus, where it is felt to be much thicker than normal. Pressure on the nerve at this site causes increased pain in the foot.

Treatment The treatment is surgical exposure of the nerve under local anesthesia and removal of the cyst.

Plantar neuritis must be differentiated from an inflammation of the plantar aponeurosis A contracture similar to Dupuytren s contracture of the hand may occur in the plantar aponeurosis There is thickening and shortening of the plantar aponeurosis with an increase of the longitudinal arch and some contraction of the toes It may occur in association with a typical contracture of the hand or it may occur alone. In the few cases that I have observed no corrective treatment was indicated except in one case where rapid growth with pain on weight bearing necessitated removal

SCIATIC INVOLVEMENT OF FOOT

Symptoms. If the sciatic nerve is inflamed true neuritis is present This inflammation causes pain on the plantar and lateral surfaces of the foot. The pain is associated with hypersensitivity of the skin which may show trophic changes the small muscles of the foot become weak and tend to atrophy, and there is diminution or absence of reflexes

More common than the true neuritis however is a referred pain, sometimes called neuralgia, which involves the lateral side of the foot and extends along the muscles of the calf and thigh This pain is due to contracture of the muscles and is frequently associated with functional decompensation of the back, sacroiliac and lumbosacral irritation spasm of the tensor fasciae latae, and pes valgoplanus

To differentiate sciatica and muscular strain, the Bragard sign is an aid. With the knee stiff the lower extremity is flexed at the hip until the patient complains of pain The foot is then brought from plantarflexion to dorsiflexion An increase of pain indicates that the nerve is involved and that a true neuritis is present since the distal branches of the nerve are stretched as the foot is brought into dorsiflexion if however this procedure produces no pain the trouble is due to involvement of the muscles on the posterior or lateral surface of the thigh (This test is not reliable if the tendo achillis is short)

Treatment Treatment must be directed against the inflamma

tion and the changes in the joints and muscles of the back and thigh although correction of the pes valgoplanus is of definite value in relieving the neuralgia This correction is carried out as described under Pes Valgoplanus

MUSCLE SPASMS AND CONTRACTURES IN THE FOOT AND LOWER EXTREMITY

A painful muscle spasm followed by contracture of the muscle occurs in the foot, leg, thigh or lower part of the back as a result of functional decompensation or static strain This type of contracture has been observed in association with low back pain and referred pain in the region of the sciatic nerve (sciatica)

Etiology The cause is an acute strain such as from prolonged standing, spasm occurs when there is an accumulation of the metabolic products in the muscle. Continuous use causes the formation of lactic acid and carbon dioxide, which are not removed rapidly enough by the circulation In the presence of a functional decompensation there is an alteration of the position of the foot and knee expressed as pes valgoplanus and genu valgum The spasm occurs during the period in which the deformity is developing The spasmodic condition may become constant, and a contracture of the muscle may result

Certain muscles are more subject to this type of contracture than others In the leg the peroneal muscles, the tibialis anterior the medial head of the gastrocnemius, and the tibialis posterior are most frequently affected by these contractures. Around the knee the sartorius and around the hip the gluteal muscles frequently show spasm The tensor fasciae latae is frequently involved both with spasm and with contracture With static changes in the lumbosacral and sacroiliac articulations, the lumbar muscles of the spine are prone to chronic muscle spasm

Occasionally an actual rupture of an intervertebral disk may give rise to pain with muscle spasm and contracture In such instances objective findings such as sensory changes motor changes or atrophy will be present

Symptoms. In the early stage of muscle spasm and contracture due to functional decompensation there is involuntary spasmodic contracture, or a cramp which lasts for a few minutes. Pain may occur during the period of strain or at night and interrupt sleep These attacks of pain occur periodically and are relieved by rest and heat with light massage There may be cramps in the foot leg thigh or lower part of the back In the later stage, pes valgoplanus

genu valgum or a pelvic tilt may be observed as the result of a contracture of the muscles. The firmly contracted muscle may be felt under the skin, and it is tender to the touch. The tendons are tight and may be seen as ridges beneath the skin; they feel like taut fiddle strings. The spasm will not subside when the muscle is relaxed by putting the limb in a flexed position.

In the final stage of this muscle spasm and contracture the acute symptoms subside, and the pain and tenderness no longer exist. The muscle is firm and decreased in size. There is atrophy of the limb and the belly of the muscle has a fibrous feel.

Treatment. Treatment is directed first against the functional decompensation. This means rest in the position of relaxation for the spasmodically contracted muscle. Circulation to the involved muscle must be improved. The extremity is elevated and moist warm packs are applied. With the limb elevated and covered by a moist towel, heat is directed on it by an infra-red lamp or a baker. This is followed by light massage, the limb being massaged with a gentle stroke sufficient to empty the veins. When there is contracture of the muscle, the treatment is carried out as above and followed by heavier massage. The fingers palpate the muscle deeply and stretch the fibers; the hand is run over the course of the muscle and tendon, and force is used to stretch the contracture. Light massage is then repeated to finish the treatment and to obtain relaxation. The associated deformity of the foot is corrected as described under Spasmodic Flatfoot.

The same principles of treatment apply for contractures of the tensor fasciae latae and the lumbar muscles. Correction of the deformity of the foot is carried out with the corrective shoe as soon as relaxation of the muscle spasm has been obtained. Weight bearing is resumed gradually; brief periods, as short as five to ten minutes at a time, are permitted at first, and are increased slowly. When it is essential for the patient to use the foot in spite of the decompensation, supportive treatment is indicated. Adhesive strapping or even a cast with a walking caliper attached may be used.

CHANGES IN THE FOOT DUE TO ANTERIOR POLIOMYELITIS

Symptoms and Etiology. Anterior poliomyelitis most frequently attacks the lower extremity. The primary lesion is in the anterior horns of the spinal cord and is due to a virus infection of the nervous system. It may paralyze either or both limbs. The limbs are not symmetrically involved. Not only are different muscles paralyzed in each extremity, but the degree of paralysis has a wide

variation The bizarre picture that results is characteristic of anterior poliomyelitis The paralysis in one foot may be complete, whereas in the other there may be only partial paralysis or even no paralysis at all In one foot the anterior group of muscles may be paralyzed, whereas in the other the posterior group may be paralyzed Thus there may be entirely different deformities in each foot

Despite these variations in involvement, however, certain types of deformity usually develop. The development of the deformity depends not only on the paralysis but to some extent also on the contracture of the opposing muscles and on the influence of gravity If all muscles that control the foot are paralyzed the foot will not remain in the midposition weight bearing forces the heel into valgus, and gravity causes the anterior part of the foot to drop This condition is known as dangle foot. If the dorsiflexors are active and if the posterior group of muscles is paralyzed, the heel is drawn forward, the height of the longitudinal arch is increased, the toes are contracted, and there is a tendency toward talipes calcaneus If the dorsiflexors are paralyzed and the posterior group of muscles is active, the force of gravity and contracture of the posterior group cause an equinus deformity When the peroneal group of muscles is paralyzed, the foot will assume a supinated and varus position *If the tibialis anterior and tibialis posterior muscles are* involved a valgus deformity with pes valgoplanus as well as foot drop is likely to develop These deformities are the residue of anterior poliomyelitis

The progress of anterior poliomyelitis is as follows First there is a short incubation period thought to be only three or four days During the period of initial infection acute symptoms arise headache, drowsiness listlessness nausea vomiting high fever and occasionally symptoms suggestive of acute upper respiratory infection Rigidity of the muscles of the neck indicates meningeal irritation the spinal fluid shows an increased cell count (lymphocytosis) and *increase of the globulin content There is flaccid* paralysis with loss of reflexes and gradual atrophy of the involved muscles At first the muscles are sensitive and movement causes pain The paralysis is usually most extensive at the onset owing to an inflammatory reaction around the nerve cells As the edema subsides the paralysis decreases Destruction of cells by the virus however results in residual anterior poliomyelitis Nevertheless improvement does take place during this residual stage There is reestablishment of some power in the involved muscles, the remaining muscle fibers hypertrophy and further function may be gained through exercises

Treatment The treatment in the early stages, for this reason, is complete rest After the inflammation has subsided, the recovery stage sets in and physical therapy may be started Rest for the foot is obtained by means of a posterior splint holding the foot at a right angle To reestablish strength in the partially paralyzed muscles, functional exercise is the most valuable. Under water exercises in a Hubbard tank, and swimming in a heated pool are excellent physiologic exercises The psychologic effect of voluntary movement is also of value.

The foot is used mainly to stand and walk. To permit weight bearing it is therefore necessary to protect the weakened muscles by means of a form fitting plaster of paris cast The muscles are in this way protected against strain during the normal exercises of standing and walking

Astounding results are frequently obtained by the application of a cast and reeducation in walking and standing in cases in which patients have been treated by massage and muscle reeducation for months without noticeable improvement. The cast is replaced within six weeks to three months by a leather and steel brace Functional exercises are continued until the maximum amount of power has been obtained in the muscles

The limb must be protected at all times to prevent contracture of the muscles with resultant deformities Braces are worn in the daytime, and splints are utilized at night. Despite treatment there is usually a residue of the paralysis and there will be a tendency toward a specific type of deformity The most frequent of these deformities is talipes equinus next talipes equinovarus, then the talipes equinovalgus and finally the dangle foot.

Talipes Equinus. Talipes equinus may occur as a result of anterior poliomyelitis. If the dorsiflexors of the foot are paralyzed, contraction of the healthy posterior group of muscles of the calf will result in a deformity Even if the posterior group of muscles is paralyzed the foot will fall into an equinus position as a result of gravity

Symptoms The first symptom noted is the characteristic position of the foot in plantarflexion the anterior part of the foot touches the floor while the heel is elevated The heads of the metatarsal bones receive increased pressure and usually the skin of the plantar surface over this area shows calluses Occasionally a small percentage of power remains in the dorsiflexors, but is not adequate to lift the foot in normal walking In these cases over a long period of time gravity may cause stretching of the dorsiflexors and result in a loss

of this remaining function The foot is short and the plantar aponeurosis is contracted and thickened. There is usually some instability of the foot and strain in the region of the ankle. The entire limb is often short as a result of the paralytic involvement, in which case a certain amount of equinus deformity results in compensatory lengthening If the length of both limbs is the same, the lengthening due to the deformity is compensated for by flexion of the knee or a

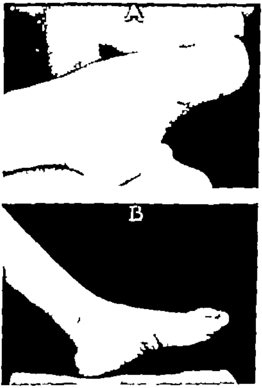


Fig 153 A, Talipes equinus due to anterior poliomyelitis Note the contracture of the great toe and the increased height of the arch B The foot after correction by the author's method

pelvic tilt. The foot is usually externally rotated ultimately this results in rotation of the tibia and valgus at the knee.

Treatment Treatment consists first in prevention of the deformity When the anterior group of muscles is paralyzed foot drop should be prevented by the application of a posterior splint at night and by a brace which has a block at the ankle joint to prevent excessive plantarflexion during the day During the residual stage walking may be started in a form fitting cast later this is replaced by the brace during the day and the posterior splint at night

Once a deformity has developed it is necessary to correct it. In young patients manual manipulation may be sufficient to obtain correction, this is retained by a plaster of paris cast. Walking is permitted on the cast, which is later replaced by a brace. Correction should be obtained as early as possible in order to permit functional exercise, that is walking in the corrected position with the protection of the brace In this way the maximum amount of muscular development can be attained The earlier normal exercise can be carried out without strain the better the result.

In older patients correction of the deformity presents a more difficult problem The short foot with a cavus deformity is corrected first by multiple fasciotomies and tenotomies The anterior part of the foot is forced into dorsiflexion with the tendo achillis acting as a resistant force. The cavus is further corrected by means of the Haglund footboard and Spanish windlass After this deformity has been corrected the tendo achillis may be lengthened subcutaneously so that the foot can be brought up to a right angle position (Fig 133) The foot is held in the cast in the midposition, and weight bearing is begun as soon as the pain subsides, which may be in one to five days The cast may be replaced by a brace with a lock at the ankle joint which allows the foot to drop enough to permit the wearing of a heel on the shoe

After the age of eight years it is possible to obtain stabilization of the foot by means of an operation so that a brace is no longer necessary This is accomplished by arthrodesis of the talocalcaneal talonavicular and calcaneocuboid articulations (Fig. 133) With the foot held in the midposition fusion of these articulations will obliterate any tendency toward lateral displacement and resultant instability

Complete foot drop can be corrected by means of posterior bone block an incision is made on the lateral side of the tendo achillis and the tendon is divided, as in tendon lengthening The lower end of the tibia the posterior tip of the talus and the posterior surface of the calcaneus are then exposed A small fragment is removed from the posterior end of the talus A large, flat block of bone is then removed from the calcaneus and turned up so that it comes in contact with the surface of the talus just below the tibia thus forming a mechanical block to prevent the foot drop.

Occasionally it may be preferable to prevent foot drop by utilizing the tendons of the paralyzed anterior muscles to suspend the foot in dorsiflexion This is accomplished by an anterior incision over the tibia Several holes are drilled through the tibia and con

nected by means of a chisel to make a large window through the tibia. The tendons of the anterior muscles are then exposed, divided, run through this window and sutured onto each other. Sufficient tension is applied to the tendons to allow for a slight stretching. The foot is usually suspended at about a right angle.

If there is an extreme equinus and cavus deformity with shortening of the foot, correction of the deformity is frequently carried out at the same time as the arthrodesis of the three articulations. This correction consists in removal of part of the head and neck of the talus, resulting in a shortened foot.

I have found it of great value in all cases, irrespective of the duration of the deformity or of the extent of the osseous changes, to carry out the manipulative correction before the fusion operation. In the adult and in fixed cases where there are bony changes, correction of the deformity may be obtained by multiple fasciotomies and tenotomies and the use of the Haglund manipulative boards. After correction a cast is applied and the corrected position is retained until weight bearing has been carried out for at least two weeks. The open operation is then carried out. This consists in fusion of the talocalcaneal, talonavicular and calcaneocuboid articulations and removal of the articular cartilages with the minimum sacrifice of bone and mutilation of the foot.

Talipes Equinovarus. It is not uncommon to see some degree of varus associated with the equinus deformity in the foot, since the peroneal muscles as well as the dorsiflexors of the foot are paralyzed. The heel goes into varus and there is adduction and supination of the anterior part of the foot in the region of the tarsal area. With varus present there is usually some power in either the anterior or posterior tibial muscles.

Symptoms. An equinus deformity is present with the heel in varus and the anterior part of the foot in adduction and supination. The foot is inverted so that the sole faces upward and weight bearing comes on the outer side or even on part of the dorsum of the foot. Callus forms over these areas after prolonged weight bearing. There is instability and a tendency toward internal rotation of the foot. Valgus deformity as well as flexion deformity may occur secondarily at the knee.

Treatment. Treatment consists in correction of the equinus and cavus deformities as described previously. The varus, adduction and supination deformities are also corrected by manipulation.

The varus deformity is corrected with the Thomas wrench. The foot is placed over a triangular block to correct the adduction. The supination is corrected by means of the mechanical lever which

forces the foot into pronation After correction of the deformities the midposition is held by a plaster of paris cast and then by a brace. In older children or adults the correction is obtained first and is followed by retention of the position by arthrodesis of the three articulations as described The talocalcaneal arthrodesis prevents recurrence of the varus arthrodesis of the talonavicular and calcaneocuboid articulations prevents the supination and adduction In this way stabilization is accomplished

If there is an extreme pull of the tibialis anterior with a tendency toward a recurrence of deformity this muscle can be transplanted from its insertion on the inner side of the foot to the dorsum of the middle cuneiform bone, so that the muscle will exert a pull directly upward instead of upward and inward.

Talipes Equinovalgus. With paralysis of the dorsiflexors and with the posterior group of muscles intact, an equinus deformity occurs Since the tibialis anterior, which is a dorsiflexor, also has a supinating action with paralysis of this muscle and with the peroneal muscles intact pronation results and a valgus is present at the heel. If the tibialis posterior is also paralyzed the valgus deformity is more severe.

Symptoms In addition to the equinus deformity, there is external rotation of the foot, abduction and valgus at the heel so that the patient walks with the flatfooted gait This type of gait gradually causes external rotation of the tibia

Treatment Treatment consists in correction of both the equinus and valgus deformities accomplished by bringing the heel into varus with the Thomas wrench At the same time the anterior part of the foot must be brought into pronation if there is to be reestablishment of the longitudinal arch With the heel held in varus the head of the first metatarsal bone is forced in a plantar direction and a cast is applied to hold the foot in the midposition The patient is then allowed to walk on the cast retaining the corrected position If arthrodesis of the talocalcaneal articulation is to be carried out the heel must be brought into midposition or slight varus Before the talonavicular and calcaneocuboid articulations are fused the anterior part must be brought into the midposition or into slight pronation

If there is enough power in the peroneal muscles so that a tendency toward deformity persists in spite of the fusion it is best to transplant these muscles The tendon of the peroneus longus may be transplanted from its external attachment to the medial side or to the dorsum of the foot

Talipes Cavus. Talipes cavus secondary to anterior poliomyelitis is a result of paralysis of the posterior group of muscles The heel

is drawn forward and downward so that the posterior surface of the foot which ordinarily projects backward is turned into a weight bearing surface. The result is a calcaneus deformity; therefore in practically all these cases one can speak of a "talipes calcaneus." The paralysis of the posterior group of muscles and the contracture of the dorsiflexors predispose to the deformity in the dorsiflexed position The ability to plantarflex the foot is gradually lost entirely If there is complete paralysis of the posterior group with retention of the dorsiflexors the calcaneus deformity is more pronounced and the cavus deformity less severe. On the other hand if the gastrocnemius and soleus are paralyzed and the other posterior muscles are still active, there is an increased cavus deformity

Symptoms In addition to the deformity, there is loss of function The foot appears to be shortened there is no projection of the heel posteriorly, the arch is increased there is a loss of ability to plantar flex at the heel the anterior part of the foot seems smaller than normal, and the toes are contracted There is contraction of the plantar aponeurosis and an adaptation of the bones to their new positions The patient walks with a stomping gait, and there is frequently instability This instability is severe if the tibialis posterior and peroneal muscles are paralyzed

Treatment Prevention of contracture is of primary importance in the early stage. Fixation in normal position must be retained until ample time has elapsed to permit maximum recovery from the anterior poliomyelitis This can be done by a light plaster cast which holds the normal position Weight bearing can be started during the period of recovery provided adequate protection of the limb is retained by a plaster of paris cast To facilitate walking a heel is applied to the cast When recovery is not expected in the posterior group of muscles, the cavus deformity may be prevented by means of a double iron brace with a form fitting foot plate and an ankle block to prevent dorsiflexion

If there is already a cavus deformity correction must be carried out before a satisfactory brace can be applied Correction of the deformity consists in manipulative stretching of the plantar aponeurosis and contracted dorsiflexors of the foot In some instances it is necessary to perform subcutaneous fasciotomy before this can be accomplished

In talipes cavus in which there is no possibility of recovery of the posterior group of muscles the most common type of correction has been astragalectomy This consists in removal of the talus and freshening of the articular surface on the inner side of each malleolus

followed by posterior displacement of the foot after the manner of Whitman It makes for definite improvement.

Fusion of the pretalus and calcaneocuboid articulations, or the Dunn type of operation, has also been carried out. The neck of the talus is divided and its head and all the navicular bone are removed The cuneiform bones are denuded to receive the neck of the talus, and the foot is displaced backward This decreases the deformity

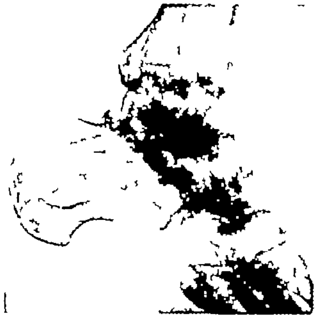


Fig. 134 Roentgenogram showing fusion of the talonavicular talocalcaneal and calcaneocuboid articulations for stabilization of the foot in residual anterior poliomyelitis

and increases the stability but, as in astragalectomy there is expensive structural loss

I use correction of the deformity followed by fusion of the talocalcaneal talonavicular and calcaneocuboid articulations In cases of long standing this requires a two-stage operation The first procedure consists in manipulation with the Haglund footboard As much stretching as possible is taken by means of the Spanish windlass. After the tissues have been thoroughly stretched a subcutaneous fasciotomy is executed at the insertion of the plantar aponeurosis into the calcaneus Multiple fasciotomies are carried out if contracted strands still exist It may be necessary to tenotomize some of the plantar tendons if they are firmly contracted After the fasciotomies and tenotomies the manipulative board is again applied

and screwed down until the foot is flat and the calcaneus is forced posteriorly. This position is held by a cast, and the patient is allowed to walk on the cast as soon as the pain has subsided, which usually takes one to three days. After correction of the deformity an arthrodesis of the talocalcaneal, calcaneonavicular and calcaneocuboid articulations is carried out through a small oblique incision over the dorsolateral area. Fusion of these articulations in the corrected position prevents the recurrence of the deformity and results in a stabilized foot without structural loss and with a relatively normal appearance.

Dangle Foot. Dangle foot following anterior poliomyelitis is caused by paralysis of all the muscles that control the foot. Gravity causes complete foot drop, and weight bearing forces the heel into valgus and pronation. This valgus may be so severe that, in addition to the deformity at the talocalcaneal articulation, there is actual stretching of the ligaments at the ankle joint.

Symptoms. The deformity usually consists in valgoplanus with foot drop, and there is external rotation on weight bearing. Appreciable atrophy and usually some shortening of the limb are also present. The disturbance in function and the instability of the foot are severe. If there is paresis of the muscles of the knee and the power of the femoral quadriceps muscle is inadequate, the patient forces the knee into extension with his hand. In some cases dangle foot permits better function than when retention of power in a group of muscles causes contracture.

Treatment. At an early age, before arthrodesis can be carried out, protection and weight bearing are made possible by a brace; this consists of bilateral irons with a lock at the ankle and a form fitting foot plate. At the minimum age of eight years, but preferably at the age of twelve to fourteen, a stabilization operation may be performed. This consists in correction of any deformity that may be present without sacrifice of bone. When there is no deformity, fusion of the talocalcaneal, talonavicular and calcaneocuboid articulations is carried out, producing a stable foot. To prevent foot drop, a posterior bone block is formed. A block of bone is raised from the calcaneus to fit behind the ankle joint under the ledge of the tibia. If the tendo achillis is contracted, this is lengthened at the same time (Fig. 135).

In many cases it is necessary to correct not only the deformity of the foot but also the deformity which may exist at the knee before doing the stabilization operation. This may require manipulation or gradual correction by means of casts and wedges, or it

may necessitate osteotomy Rotation flexion and valgus occasionally exist at the same time and a supracondylar operation is indicated First the maximum amount of correction should be obtained gradually through the cast treatment If osteotomy is necessary extreme precautions must be taken in obtaining the correction in order not to injure the nerves or vessels

After the deformity of the limb has been corrected and the foot has been brought into normal position weight bearing should be



Fig. 135 Campbell bone block to prevent foot drop in case of dangle foot secondary to poliomyelitis Note also fusion of talocalcaneal talonavicular and calcaneocuboid articulations

carried out in the cast The stabilization operation and bone block can then be carried out with the best results

Tendon Transplantation in Anterior Poliomyelitis The use of tendon transplantation as an operation per se for correction of anterior poliomyelitis is limited In every case, before transplantation is carried out all deformities must be corrected

If there is a definite imbalance of muscles due to the existence of one group with loss of the opponent it is best to carry out correction of the deformity and a stabilization operation and then to transplant the tendon of the active muscle into the optimum position For instance if the peroneal muscles are pulling the foot into

valgus and if there is weakness of the posterior group of muscles after the arthrodesis has been carried out the peroneals are transplanted from their lateral insertion into the tendo achillis to aid the posterior group Likewise if the tibialis anterior is normal and the peroneals are paralyzed the tendency toward further varus deformity can be obliterated by transplanting the tibialis anterior into the midline on the dorsum of the foot.

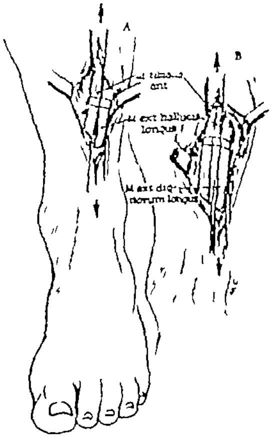


Fig. 136 Tendon suture used in cases of paralysis of the anterior tibial muscle

More frequently the tibialis anterior is paralyzed and there is strength in the extensors of the toes and the peroneals In these instances I use a procedure after the manner of Haglund which preserves the intended function of the tendons and at the same time acts through the paralyzed tibialis anterior A longitudinal incision is made to expose the tibialis anterior the extensor hallucis longus and the extensor digitorum longus With the foot in dorsiflexion the distal part of the paralyzed tibialis anterior is drawn up and sutured to the tendons of the vital muscles All three muscles act as a single

unit to dorsiflex. This gives the maximum amount of power and prevents deformity (Fig 136)

In foot drop the extensor hallucis longus often retains its power This unopposed extensor causes flexion of the great toe (hammer toe) and increase the cavus deformity of the foot

After the correction of the deformity and the fusion operation it is frequently advisable to transplant the insertion of the extensor hallucis longus into the head of the first metatarsal bone. This is accomplished through a small dorsal incision A hole is drilled through the shaft of the bone immediately posterior to the head and the tendon is drawn through and fastened upon itself If desired the distal end of the extensor hallucis longus may be fastened to the common extensor tendon The power exerted on the head of the first metatarsal bone, plus the remaining power of the tibialis anterior has in several cases proved adequate to permit dorsi flexion making bone block unnecessary

SPASTIC PARALYSIS OF THE FOOT

Spastic paralysis of the foot rarely if ever occurs alone, it is usually associated with monoplegia of the lower extremity or with hemi plegia of a particular side, it may be cerebral (cortical or subcortical) or spinal (pyramidal tract) In spinal cord disease there is more likely to be a bilateral involvement a paraplegia or a quadriplegia The loss of function in the limbs is due to paresis produced by an upper motor neurone lesion

Etiology In childhood the lesion is almost always caused by intra cranial hemorrhage or trauma occurring at birth Occasionally there is congenital absence of cortical pyramidal substance; in such cases the *prognosis is poor* In the adult spastic paralysis may be due to sclerosis of the spinal cord cysts emboli, thromboses, or rupture of the vessels

Symptoms. The symptoms of spastic paralysis of the foot are those caused by increased tone, that is irritability of the muscles and a tendency toward spasm There is increased reflex activity and pathologic reflexes are present. Light stimulation on the sole causes extension and spreading of the toes instead of normal flexion (Babin ski reflex) Ankle clonus is frequently present, there is little or no atrophy The foot usually assumes an equinus position associated with a varus and occasionally with a valgus There is a tendency to walk on the toes with the foot internally rotated The entire limb is involved the knee is in flexion and there is an adduction and in ternal rotation deformity at the hip

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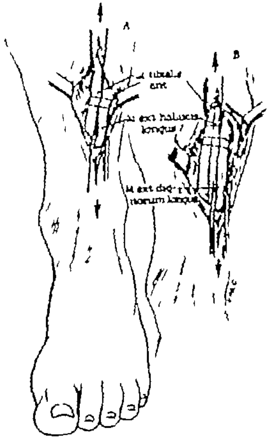


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Spastic paralysis of the foot may be associated with focal or generalized epilepsy occurring particularly after birth trauma Occasionally there is an associated impairment of mentality which aids in making the proper diagnosis The prognosis depends on the severity of the trouble it is usually more favorable if only one limb is involved. A low mentality as well as epilepsy is an unfavorable sign

Treatment Treatment consists first in decreasing the heightened reflex activity Control of the situation frequently lies in correction of the deformity and reestablishment of the normal function of the limb Since spasticity is caused by stimulation of the hypersensitive nervous system protection by means of a well padded cast with the limb in midposition brings about the maximum amount of relaxation possible After the peripheral stimuli are at a minimum, an attempt is made to reestablish muscular control This is best accomplished by attempting to carry out normal function that is normal walking

The spastic foot usually assumes an equinus position Correction of the equinus is essential for reestablishment of function since with this deformity the patient must walk on his toes with an awkward gait in which the extremity is circumducted and the body *weight is out of balance With correction of the equinus the weight* bearing goes through the heel, normal posture may be assumed at the knee, and the center of gravity falls through a more normal line The equinus is corrected by an operation to lengthen the tendo achillis so as to bring the foot to a right angle position Too much lengthening would result in weakening of the posterior group of muscles and cause a talipes cavus deformity too little would result in a recurrence of the deformity

Accurate correction of the disorder brings about not only improved weight bearing but also better muscular balance The posterior group of muscles which are the stronger are weakened by the tendon lengthening With improved balance between the anterior and posterior groups of muscles normal function can be carried out more readily and there is less danger of recurrence of the deformity

Under no circumstances should tenotomy of the tendo achillis be done *for this owing to the spastic muscles would result in retraction of the tendon and ultimately in talipes calcaneus*

The open operation is frequently recommended as the operation of choice I find it easier to obtain the optimal amount of lengthening by the closed method After the open operation there are more

adhesions along the tendon sheath, on the other hand the closed method requires experience and the utmost care

In the diplegias the treatment recommended is to include both lower extremities and the pelvis in a cast that reaches up to the lumbar area The use of this soft bed for a period of several weeks tends to improve the general condition by reducing to a minimum the peripheral stimulation thus diminishing reflex activity A walking cast is then applied and reeducation of gait is secured by means of a walker

In the hemiplegias the severity of the spasticity varies a great deal and the treatment must be modified accordingly If the spasticity is great a well-padded cast is worn while the patient rests in bed for several weeks and is followed by a walking cast. In the milder cases the patient starts with a walking cast After the operation for lengthening of the tendo achillis the entire limb is enclosed in a cast. After three weeks the original cast may be replaced by a small one which includes only the foot and calf A low heel is applied to the cast and the patient can then walk with a relatively normal gait The cast is worn for four to twelve weeks Occasionally this is followed by a brace having bilateral irons with a foot plate

The spasticity is sometimes so slight that it cannot be detected in early childhood The parents may or may not notice that the child uses one foot more awkwardly than the other particularly in running As the child grows older however this becomes more noticeable Careful examination will reveal increased reflexes not only at the ankle, but frequently also at the knee. In such cases correction by tendon lengthening followed by a plaster of paris cast, usually reestablishes normal function

The result of treatment of spastic paralysis in the foot depends to a great extent upon the cooperation of the patient and this in turn depends upon his intelligence Correction of the deformity in an imbecile is useless The higher the patient s intelligence quotient and the better his training the better will be the result following any surgical correction

Spastic paralysis in the adult is often essentially a medical problem The equinus deformity however is frequently a source of great discomfort and relief of the circumduction gait caused by the spastic equinus is gratefully appreciated In this type of case the most satisfactory and practical treatment is the use of the single iron brace with a spring to bring the foot into dorsiflexion (see Fig 193, p 403)

REFERENCES

Betts, L. O Morton s Metatarsalgia Neuritis of Fourth Digital Nerve. Med J Australia, *1* 514 1940

Bickel, W H., and Moe, J H Translocation of the Peroneus Longus Tendon for Paralytic Calcaneus Deformity of the Foot Surg., Gynec. & Obst., *78* 627 1944

Campbell, W C. Bone-Block Operation for Drop-Foot. J Bone & Joint Surg., *12* 317 1930

Dunn N The Surgery of Muscle and Tendon in Relation to Infantile Paralysis. *Proc. Roy Soc. Med., Part I 22*.243 *1928*.

Hauser E. D W Correction of Deformity as a Routine Procedure Before Stabilization Operations of Lower Extremity Surg., Gynec. & Obst., *55* 569 1931

Lambrinudi, C New Operation on Drop-Foot Brit J Surg., *15* 193 1927

McCarroll, H R. Foot Deformities Resulting from Irreparable Nerve Lesions Am. Acad Orth Surgeons Reconstruction Surgery of the Extremities Ann Arbor Mich., J W Edwards, 1944

McElvenny R. T The Etiology and Surgical Treatment of Intractable Pain About the Fourth Metatarsophalangeal Joint (Morton s Toe) *J Bone & Joint Surg., 25*-675 1943

Pollock, L. J., and Davis, L. Peripheral Nerve Injuries New York, Paul B Hoeber Inc., 1933

22

DISEASES OF THE BONES AND JOINTS

TUBERCULOSIS OF THE TALOCRURAL AND TALOCALCANEAL ARTICULATIONS

(*Tuberculosis of the Ankle Joint*)

Of the articulations of the body which become involved in tuberculosis, the talocrural is the third most frequently affected. Tuberculosis of this articulation gives rise to severe disability inasmuch as it is a weight-bearing joint.

It is difficult to establish the diagnosis early. The synovial fluid is aspirated and smears are made of the centrifuged fluid to find the tubercle bacillus. The fluid is also injected into a guinea pig, which is examined six weeks later for the bacillus.

Etiology. The cause of the condition is the tubercle bacillus. When an ankle is affected, the patient should be examined thoroughly for infection elsewhere in the body. Tuberculous pleurisy or erythema nodosum is sometimes found. These patients usually give a history of a slight twist of the foot or a sprain of the ankle.

Symptoms. The symptoms are pain in the ankle which is worse on weight bearing, the presence of a limp, and slight swelling and tenderness over the articulation. The symptoms may persist for some time without great articular changes. In the moderately advanced stage swelling is seen anterior to the articulation as well as below the malleoli. There is limitation of motion at the talocrural articulation. If the talocalcaneal articulation is also involved, there is limitation of lateral motion, and attempts at lateral movement of the heel cause pain. There is atrophy of the calf muscles. The roentgenogram shows loss of joint space with erosion of the articular surface and osteoporosis of the bones. In the late stages sequestra may be seen.

The tuberculosis may affect either the talocrural articulation alone or the talocalcaneal articulation alone (Fig. 137), but both are usu-

ally involved In the late stage the ankle becomes much enlarged so that the malleoli *can no longer be seen, abscesses* may be palpated, and finally fistulae occur Rarely abscesses are found in the surrounding tissue occasionally the suppurative material will follow *the tendon sheath into the leg.*

Tuberculosis of the ankle varies a great deal in its virulence Some people have little resistance, and destruction goes on rapidly whereas others show a greater power for healing The tuberculosis may occur in the synovial sheath or directly in the bone, either the lower end of the tibia or the talus Healing may take place with conservative treatment in the benign cases particularly in children When the



Fig. 137 Destructive arthritis of A, the talocalcaneal and B talocrural articulations due to tuberculosis

tuberculosis has become quiescent without bony ankylosis there may be recurrences

Treatment *Conservative Treatment* Conservative treatment is the treatment of choice in children surgical intervention being resorted to only as an occasional adjunct under unusual circumstances. It may be necessary to puncture an abscess or perform sequestrectomy or rarely to remove the talus but no extensive operation is ever executed until the general tuberculous infection has subsided.

Conservative treatment is carried out in adults for a period adequate to establish the virulence of the infection and to determine the resistance of the body Sometimes the indications for surgical intervention may be obvious at once at other times it may be necessary to continue the conservative treatment for more than six months *before it can be established that surgical intervention is necessary* When tuberculosis is suspected but the diagnosis cannot be estab-

lished, the condition is treated on the assumption that the tuberculosis exists This means fixation with a plaster of paris cast and observation by roentgenogram General hygienic measures are carried out, including rest, fresh air, sunshine, a high-vitamin diet plus cod liver oil and dicalcium phosphate The amount of sunshine is controlled. In the winter months the carbon-arc lamp may be used

Operative Treatment Operative treatment for tuberculosis of the ankle is limited to adults who do not respond to conservative treatment. If the talocrural articulation alone is affected it is fused Astragalectomy is resorted to only when an extensive tuberculous osteitis makes fusion practically impossible.

In most cases fusion of the talocrural articulation is not sufficient and the talocalcaneal articulation must be fused at the same time The operation is carried out under general anesthesia and the tourniquet a vertical incision is made posterior to the fibula starting about 2 inches above the lateral malleolus and curving around it to the dorsum of the foot. Both peroneal tendons the lateral ligament and the joint capsule are divided so that the foot may be brought into extreme varus and the talocrural articulation is exposed All tuberculous tissue is removed The tibiofibular syndesmosis is resected In order to bring the fibula into contact with the denuded surface of the talus, the fibula is cut through with an osteotome To fuse the talocalcaneal articulation, this joint is exposed, the articular cartilage is removed, and the denuded surfaces are brought into contact When astragalectomy is indicated, the talus is excised and all the tuberculous tissue, including the synovial lining, is dissected

After operation a plaster of paris cast is applied with the foot in 5 to 10 degrees plantarflexion to allow for the heel of the shoe—usually about 10 degrees for women and a little less for men After four weeks a new cast is applied over stockinet without padding Weight bearing is begun after four to ten weeks depending on the acuteness of the tuberculous process Fixation must be carried out until bony ankylosis has taken place, as established by means of a roentgenogram Weight bearing may be begun in the cast by applying a heel to it, or a walking caliper may be used

After astragalectomy the foot is displaced posteriorly with regard to the tibia and fibula to obtain better weight bearing A cast is then applied and fixation is carried out for a period of at least two months During the process of healing the cast may be replaced by a form fitting brace of leather and steel

In some cases after the articular surfaces are denuded bone grafts taken from the tibia may be utilized to obtain further fixation by

placing them from the tibia to the talus or to the calcaneus The destructive process may be so great and the response to treatment so poor that in order to reestablish function it may be necessary to amputate.

TUBERCULOSIS OF THE TARSAL BONES AND JOINTS

The cuboid and navicular bones are most frequently involved Usually, when a tarsal bone is infected the infection spreads to the neighboring articulation More than one tarsal bone is frequently diseased and the talocrural articulation is often included.

Symptoms. There is tenderness and swelling over the tarsal area and pain on weight bearing and with motion either pronation or supination of the anterior part of the foot Muscle spasms occur and inversion and eversion are limited The tarsal bones are more frequently involved in children than in adults The roentgenogram shows loss of joint space, destruction of the bone, and osteoporosis.

Treatment. In children the treatment is always conservative. Weight bearing is removed until the acute symptoms have subsided, and a plaster of paris cast is applied with the foot in the midposition. General hygienic measures are important these include heliotherapy a high calorie-high vitamin diet, dicalcium phosphate with viosterol fresh air and general rest. Time is an important therapeutic measure; enough must be allowed to permit complete healing

In the adult if tuberculous osteitis is limited to a single bone it may be possible to remove this bone and obtain a cure. In most cases however, the articular surfaces are involved and when conservative treatment has not resulted in a healed process with fusion it may be *necessary to expose the adjoining articular surfaces* and denude the bone to bring about a solid bony fusion and expedite healing As long as the process is active to the extent that it is spreading from one bone to another it is necessary to carry out conservative treatment When tuberculosis is present elsewhere in the body and the process is diffused through the tarsal as well as the crural area amputation may be the procedure of choice.

TUBERCULOSIS OF THE TENDON SHEATHS

This is an extremely rare condition usually associated with tuberculosis of the talocrural articulation The peroneal tendon sheath may be involved as may also the sheath of the extensor digitorum communis Characteristic are the rice bodies found within the synovial sheaths Treatment consists in dissection and removal of the infected tendon sheath

SYPHILIS OF THE FOOT

Periostitis, osteitis of the bones of the foot, and a painful or tender tendo achillis may be caused by syphilis. Gummas and chronic indolent ulcers on the plantar surface of the foot may occur as a result of syphilis A diagnosis should not be arrived at until a Wassermann test has been made.

Treatment is the same as for syphilis in general

CHARCOT'S DISEASE OF THE FOOT AND ANKLE

Charcot s disease is a trophic disturbance of the joint It is usually, but not necessarily syphilitic It may be secondary to a lesion of the



Fig. 138 Charcot s disease of the ankle joint Note destruction with bizarre overgrowth

spinal cord as a result of trauma or pressure. Swelling of the joint and hypermobility with absence of pain are characteristic.

Etiology The condition is due to a neurotrophic disturbance associated with trauma The trauma causes destruction of the diseased joint The absence of nerve control results in an extraordinary type of reconstruction and the result is a bizarre picture of destruction and overgrowth

Symptoms. The joint is swollen with increased fluid it is usually painless and has increased mobility giving rise to instability Weight bearing increases the destruction and the condition grows slowly

but progressively worse. Ordinarily the condition is limited to a single joint, the talus being most frequently involved. When the ankle joint is affected, there is a flattening and broadening of the talus; the joint is usually subluxated laterally and sometimes anteriorly or posteriorly. There are obvious changes at times in the talocalcaneal articulation. The talus and the calcaneus may be affected to the extent that there is entire disintegration of these bones.



Fig. 139. Charcot's disease of the ankle.

A roentgenogram will show the bizarre picture, with the marked exostoses and destroyed areas as well as loose bodies. Atrophic and sclerotic changes of the bone are seen in the same roentgenogram (Figs. 138 and 139). Exostoses are sometimes seen in the region of the insertion of the tendo achillis into the calcaneus as well as in the region of the insertion of the plantar aponeurosis into the calcaneus.

Treatment. Antisyphilitic treatment must be carried out. In addition, protective measures for the joint by means of a cast and a form-fitting brace of leather and steel are of value in preventing further destruction and in increasing the stability of the ankle and foot.

Attempts at arthrodesis have not been entirely satisfactory, but when there is little trophic disturbance and the infection is controlled, it may be considered to obtain stability

GONOCOCCAL ARTHRITIS OF THE ANKLE

Inflammation of the ankle joint may occur as a serious and painful complication of gonorrhea It is said to be found in about 2 per cent of the cases infected and the ankle is second to the knee in frequency of involvement

Symptoms A painful joint is frequently the earliest symptom At first there may be spasmodic stabs of pain, later the pain may become constant The joint becomes swollen and local heat is present An area of local redness gradually appears and the slightest motion at the ankle causes an exacerbation of sharp pain The arthritis is usually associated with a rise of body temperature. There is also an increase of synovial fluid At first this is purely a serous effusion some organization then gradually takes place, and there is a tendency toward adhesions between the joint surfaces Changes in the joint surfaces occur early

Occasionally the infection causes pus formation within the joint cavity Such a joint is extremely painful and there is a tendency toward rapid destruction of the articular cartilage The surrounding tissue of the ankle joint shows signs of reaction toward the infection There is edema and infiltration of the synovial and periarticular structures

The severity of the infection varies There may be a painful low grade, indolent arthritis but in most cases there is a sharp acute attack with malaise and rapid rise of fever In some cases the temperature rises to 104° or even 106° F

Treatment. Adequate treatment must be directed against the primary infection Penicillin in doses of 300 000 to 600 000 units daily for two to four days has been found effective in treating not only the primary infection but the joint involvement as well. Occasionally supportive therapy must also be instituted Fluids are forced by mouth and the intake and output measured the daily output should be about 1500 cc The limb must be put at rest and a posterior metal splint or molded plaster of paris cast is utilized In the most acute stage the limb can be held by a pillow splint or a compression bandage of sheet wadding reinforced with gauze and adhesive strapping If the synovial fluid has increased so that it causes tension the joint should be aspirated If the inflammation persists and a high fever

in spite of adequate general treatment it may be necessary to open the joint on both sides and wash it out with large quantities (1000 cc.) of saline solution

Fixation of the joint is retained until the acute symptoms have subsided. Active motion is started as soon as the inflammation has abated and the pain has decreased Gentle massage may be utilized to relieve the periarticular swelling and will help relax the muscle spasm Occasionally after the inflammation has subsided and motion has been begun the joint is protected with a plaster of paris cast with a walking caliper attached to permit early weight bearing After the cast is removed a support may be utilized in the shoe, usually a felt pad in a stiff shanked shoe During this period heat and massage are continued until the normal range of motion has been reestablished

Hyperthermal therapeutics was a great improvement over previous methods of treatment of gonococcal infection but this form of therapy has now been replaced by penicillin

Sulfa drugs are likewise valuable in the treatment of gonococcal infections Either the oral or intramuscular preparation may be used the amount prescribed being regulated by the blood content. Sulfadiazine in the blood can be measured and for the optimum therapeutic effect the blood content should be from 5 to 10 mg per 100 cc Leukopenia is a contraindication to its use, and the blood count should be checked frequently

PYOGENIC INFECTION OF THE TALOCRURAL ARTICULATION

An acute suppurative arthritis of the talocrural articulation may occur as a result of an infection with pyogenic organisms such as *Staphylococcus aureus* or *Streptococcus haemolyticus* or rarely as seen in the foregoing section a gonococcus The infection may be introduced directly from the outside through a puncture wound it may be secondary to an osteomyelitic abscess which breaks into the articulation or it may be introduced from the blood stream It frequently occurs in children (Fig 140)

Symptoms. The onset is often sudden and the local symptoms may be preceded by a chill rapidly rising temperature and an increase in the pulse rate The articulation becomes intensely painful movement causes excruciating pain There is swelling and redness with local heat around the ankle an increase of synovial fluid and a rapid involvement of the periarticular tissue The entire joint is inflamed soon after it becomes infected The synovial membrane is red and thickened and granulation tissue forms After the appear

ance of pus the joint cartilage is soon destroyed. The fever is high, from 103° to 106° F, and there is a high leukocyte count with a predominance of polymorphonuclear cells

Treatment If the articulation is infected, immediate aspiration is *indicated* *Smears* are *made* of the synovial fluid in an attempt to identify the bacteria, it may be necessary first to centrifuge the synovia If there is pus and if the local reaction is severe, or if there is evidence of general toxemia, the articular cavity should be opened at once *through two small incisions one on the medial side and the* other on the lateral side, and washed out with sterile normal saline solution The sterile fluid is allowed to flow through the joint until it returns clear, 1 liter or a good deal more may be necessary before the



Fig 140 *A*, Ankylosis of the talotibial and talocalcaneal joints following a compound fracture with pyogenic infection. *B* Photograph illustrating residual motion with good functional result.

joint is thoroughly cleansed The wounds may then be closed and a compression bandage of sheet wadding applied, with a posterior splint of plaster of paris to keep the articulation at rest.

If the symptoms continue and the cavity refills with pus, it may be necessary to remove the skin sutures and wash it again When the infection is virulent and the patient's general resistance extremely low the *joint is not closed* *Blood transfusions* are used to improve the general condition of the patient and it is sometimes necessary to repeat the transfusion of 500 cc of citrated blood on several occasions. As the patient improves and the infection subsides, the small wound will close spontaneously and active motion is encouraged In two cases in which streptococcic suppuration was present in an articulation irrigation with large quantities of saline solution was later supplanted by irrigations with 1 per cent mercurochrome through the medial and lateral openings of the joint, with excellent end results Usually the joint is closed after the irrigation and kept at rest until the acute inflammation has subsided, after which active

motion is instituted and heat and massage are used as further ad juncts in reestablishing normal function

If on aspiration the synovial fluid shows pus but the general reaction is slight it may not be necessary to open the joint A single aspiration followed by a compression bandage and fixation with a posterior splint may be sufficient treatment to combat the infection Occasionally the synovial fluid increases after such an aspiration without much general reaction in which case the aspiration may be repeated The aspirated fluid may not show pus and in this case

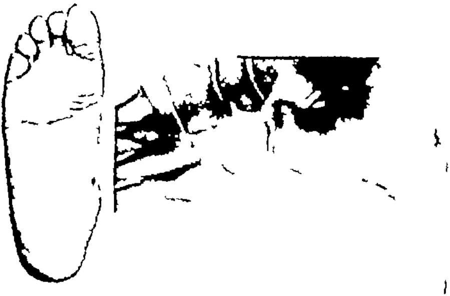


Fig. 141 Brucellosis involving the sole of the foot

a compression bandage is applied and the joint is kept at rest When there is no longer an increase of synovial fluid and the fever has subsided motion may be started With the subsidence of pain weight bearing is permitted

The early administration of antibiotics greatly reduces the morbidity and minimizes joint destruction Penicillin streptomycin and the sulfa drugs have all been found useful Penicillin is usually preferable If the response is not satisfactory the sulfa drugs or streptomycin can be used

OSTEOMYELITIS

Osteomyelitis of the foot secondary to septicemia is relatively rare (Fig 142) When a primary infection occurs it usually affects the calcaneus Osteomyelitis may occur secondary to trauma in this case the metatarsal bones are most frequently involved

Osteomyelitis of the Calcaneus. Osteomyelitis may occur in the calcaneus in association with osteomyelitis elsewhere in the body or secondary to a furunculosis It is an infection with pyogenic bacteria which enter the blood stream and localize in the calcaneus where they invade and destroy the tissue

Symptoms The symptoms of osteomyelitis of the calcaneus are similar to those of osteomyelitis in other bones in the body There may be systemic symptoms such as weakness and malaise; fever and a high leukocyte count may be present. The most common local symptom is an aching of the heel This may vary greatly in intensity



Fig 142 Chronic osteomyelitis of the tibiae forming Brodie's abscesses

Frequently associated is a stiffness of the foot due to a protective muscle spasm Depending on the acuteness and the severity of the involvement pain may be extreme and there may be an accompanying swelling with redness in the area of the heel and tenderness to touch A chronic osteomyelitic infection of the calcaneus is sometimes difficult to recognize from the symptoms alone and a roentgenogram will aid in the diagnosis

Treatment When a diagnosis of osteomyelitis is established, antibiotics are administered Penicillin in doses of 300 000 units daily is satisfactory to maintain adequate blood levels. Usually this will result in immediate subsidence of symptoms and gradual healing as evidenced by the roentgenograms Occasionally a cystlike area will persist without change despite prolonged treatment When this occurs it may be advisable to correct the bony defect with surgery An incision is made over the cystlike area and a small drill is used

to open the roof of the cavity to locate accurately its position and extent The entire roof is then removed with an osteotome, and the walls of the cavity are curetted to remove the false lining of granulation tissue. The cavity is then filled with bone chips obtained either from its walls or from the crest of the ilium The wound is closed primarily and a plaster of paris cast is applied to permit early walking Penicillin is continued postoperatively until all danger of infection has passed



Fig 145 Healed osteomyelitis of the fifth toe

In chronic osteomyelitis involving the calcaneus the central part of the bone may be affected and in order to obtain adequate drainage it has been found advantageous to approach the calcaneus by means of a split heel incision This means a posterior incision which is extended along the plantar surface of the heel The heel is then divided in halves and in this way access is obtained to all the infected area The sequestra are removed and the abscessed cavities are obliterated using spongy bone obtained from the ilium The wound is closed primarily Antibiotics are administered preoperatively and postoperatively to insure primary healing

Osteomyelitis of the Metatarsal and Tarsal Bones. Osteomyelitis of the metatarsal or tarsal bones is usually secondary to a crushing injury, a compound fracture, or a severe infection of the foot (Fig 143)

Symptoms The symptoms are essentially those of a similar infection in other parts of the body

Treatment Before treatment is started, a culture is taken Treatment consists, first, in thorough but gentle cleansing of the tissues The wound is washed with soap and warm water for ten minutes and rinsed off with sterile water The surgeon wears sterile gloves. The wound is then covered with a sterile dressing and the limb is kept at rest. If the wound is on the dorsal area, a posterior splint is used. The limb is elevated about the height of an ordinary pillow, and warm moist sterile dressings are applied

The culture will determine the appropriate sulfa drug or antibiotic to be administered. The wound is dressed daily and gently cleansed at each dressing. This is continued until the infection subsides If the infection localizes to form an abscess in the bone, drainage can be obtained and the area packed with petrolatum dressing.

Surgical intervention is avoided unless unquestionably indicated Indications for surgery are persistent localized abscess following prolonged treatment with penicillin, or the presence of a sequestrum Drainage of the abscess is obtained by opening the cavity with a minimum amount of trauma to the surrounding tissue. Any sequestra present are removed Then the walls of the cavity are broken down with an osteotome and the spongy bone thus obtained is used to fill the cavity

The principal treatment for infection is rest and this is true of osteomyelitis Rest is obtained by a plaster of paris cast into which a window is cut if it is necessary to dress the wound. In this way the limb can be elevated to facilitate circulation and to prevent edema and swelling The cast also facilitates early reestablishment of function

OSTEOCHONDRITIS DISSECANS

Osteochondritis dissecans is a rare condition in the foot (Fig 144)

Etiology The cause is unknown the disease is probably due to a localized vascular occlusion with cartilaginous degeneration in the area supplied by the involved vessel Trauma may be a predisposing factor

Symptoms. The symptoms are pain in the involved joint possibly with recurrent acute swellings. Crepitation is frequently present. The roentgenogram is important when a loose body is present or a defect occurs in the joint surface. Multiple roentgenograms from various angles may be necessary in order to make the diagnosis.

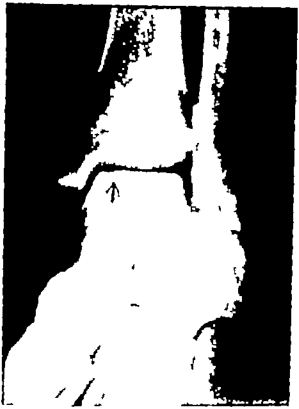


Fig 144 Osteochondritis dissecans of the medial surface of the talus

Treatment. Treatment consists in correction of the faulty mechanics in the foot and surgical excision of any loose bodies present.

GOUT

Acute recurrent painful and tender swelling of the metatarsophalangeal joint of the great toe is characteristic of gout. Various bones or joints may be involved. Salts of uric acid are deposited in the regions affected and chronic arthritis may develop. Gout is characterized by abnormal metabolism of purines with resultant uricacidemia and an increased uric acid content of tissue fluids.

Etiology. The cause of gout is unknown. Heredity, food and drink may be predisposing factors. The disease is uncommon before the third decade of life. Men are much more frequently affected than

women Paroxysmal attacks may be precipitated by excessive eating alcohol trauma or physical and nervous strain

Symptoms The symptoms of acute gout are striking there is an extremely painful swollen red articulation appearing rather suddenly usually following a dietary indiscretion Premonitory symptoms are common and fever is usually present. A high uric acid content of the blood is of diagnostic value but may be absent in early acute attacks 1 5 to 3 5 mg per 100 cc. is considered normal, 4 or over is abnormal

In chronic gout hyperuricemia is practically always present There are usually osseous overgrowths over the articulation and



Fig. 145 Gouty involvement of the first and fifth metatarsal heads

palpable uric acid deposits There is some limitation of motion The roentgenogram shows noticeable change, the head of the first metatarsal bone may show a spotted area and decreased density as well as hypertrophy due to the deposits The bursa is thickened and there is a periarticular swelling (Fig 145)

Treatment If there is a family history of gout or if one attack has been experienced obesity should be avoided purine rich meats omitted alcohol forbidden and regular exercise instituted

Acute attacks require immobilization of the involved joint Salicylates with sodium bicarbonate may relieve pain if not morphine should be used Colchicum and cinchophen and their derivatives are considered specific Colchicine 1 mg four to five times daily for one or two days after which the dosage is reduced or tincture of colchicum 15 to 20 minims every three or four hours is used Cinchophen (atophan) or neocinchophen (tolysin) give relief but

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they have produced liver atrophy and are considered too dangerous for general use.

Dietary measures are of fundamental importance. As has been said, obesity should be avoided and the intake of purines radically reduced. Accordingly, alcohol is forbidden and meats (especially liver and sweetbreads, meat juices and extracts, fish, fowl), peas, beans and mushrooms are strictly limited in the diet. Protein is supplied through eggs, cheese and milk. Cereals, green vegetables, fruits, butter, lard, tea, coffee and cocoa are allowed. It is important to carry out exercises, particularly outdoor exercises, to help eliminate the metabolic products of the nucleoproteins.

When the acute symptoms subside, a loose fitting shoe is worn with pads applied inside to take the weight off the head of the metatarsal bone. This is accomplished by the use of a large felt pad formed into an inclined plane, directing the weight from the medial side of the foot to the outside.

Since trauma to the metatarsophalangeal articulation is a factor in causing the irritation, reestablishment of normal position of the foot and normal gait is important. In many cases of gout there is supination of the anterior part of the foot. This is corrected after all acute symptoms of the gout have subsided by wearing the corrective shoe with the comma-shaped bar in an inclined plane directed medially. (See treatment for Pes Valgoplanus.)

CHRONIC INFECTIOUS ARTHRITIS

In the presence of a generalized chronic infectious arthritis, the foot is frequently affected, since weight bearing subjects the articulations of the foot to repeated irritations. There may be pain without swelling, or the foot may show signs of acute inflammation. The weight bearing surface of the calcaneus may become inflamed, causing a painful heel. Arthritis of the ankle joint gives rise to serious disability, particularly if there is destruction of the articular cartilage (Fig. 146).

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limitation of motion, muscle spasm and sharp pain with passive movement The foot is painful even when at rest and stiff when used after rest With use, the stiffness gradually leaves, but after prolonged use, the pain is increased

Treatment It is most important to keep the articulations at rest until the inflammation subsides The foot is elevated and held

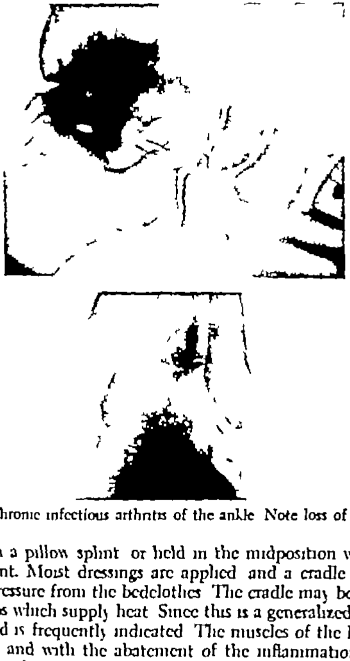


Fig. 146 Chronic infectious arthritis of the ankle Note loss of joint space

quiet with a pillow splint or held in the midposition with a posterior splint. Moist dressings are applied and a cradle is used to prevent pressure from the bedclothes The cradle may be equipped with lamps which supply heat Since this is a generalized infection rest in bed is frequently indicated The muscles of the leg may be massaged and with the abatement of the inflammation the area of the articulations may be stroked lightly Active motion is permitted as the pain subsides When weight bearing may be per

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Symptoms Symptoms of nonspecific infectious arthritis of the foot are pain swelling, local heat and redness over the articulations The metatarsophalangeal articulations particularly of the great toe, are a common site. The talocalcaneal or talocrural articulations, when affected cause serious disability The articulations of the tarsal area may be attacked but this is less frequent There is pain on weight bearing which is increased with movement at the articulations There is limitation of motion During an acute attack the inflammation may be intra-articular or periarticular there is increased

limitation of motion muscle spasm and sharp pain with passive movement The foot is painful even when at rest and stiff when used after rest. With use, the stiffness gradually leaves, but after prolonged use, the pain is increased

Treatment It is most important to keep the articulations at rest until the inflammation subsides The foot is elevated and held



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mitted the articulations are protected either by a form fitting plaster of paris cast or by a Gibney bandage. When the patient has been in bed for a long time, the structures are weakened and a form fitting arch support should be used temporarily This is replaced later by felt pads in a stiff-shanked shoe, adhesive strapping may be used to give additional protection To reestablish normal strength the corrective shoe is used as described for the weak foot

Chronic infectious arthritis is essentially a medical problem which includes the removal of the focal infection and measures to increase the patient s general resistance, such as vitamins liver iron vaccine and hyperpyrexia The local treatment of chronic infectious arthritis consists in relieving the pain, resting the part until the inflammation subsides prevention of deformity guarding against loss of motion and reestablishing normal strength

In neglected cases with contracture and limitation of motion the position of the foot must be improved in order to reestablish function

The generalized infection must have subsided before correction of the deformity is begun Under anesthesia the articulations are manipulated with caution The structures are stretched with a minimum amount of trauma An inflammatory reaction follows the stretching of the ligaments and breaking down of the adhesions To obtain rapid subsidence of this inflammation the manipulated foot is held at rest with a well padded plaster of paris cast As soon as the pain subsides which may take from twenty four hours to ten days, the cast is bivalved heat and massage are started and active motion without weight bearing is encouraged

Treatment of this phase may also be carried out with the application of a form fitting plaster of paris cast with walking caliper attached In this way weight bearing exercises are carried out with sufficient protection to prevent strain and allow for adequate movement to prevent recurrence of stiffness Muscular power is reestablished while walking in the cast

Tenosynovitis Due to Chronic Infectious Arthritis. Tenosynovitis is inflammation in a tendon sheath it may occur secondary to chronic infectious arthritis The sheath of the tendo achillis is the most frequent site of this condition

Symptoms There is tenderness swelling and pain on movement of the involved tendon When the tendo achillis is affected there is pain on walking and standing The patient walks with a flatfooted gait to avoid use of the posterior group of muscles

Treatment If the tendo achillis is involved treatment consists in

rest by means of fixation A posterior molded splint of plaster of paris may be utilized to fix the foot in slight plantarflexion and the heel is raised by a sponge rubber pad in the shoe This raised heel makes it possible for the foot to roll off the floor with a minimum amount of use of the posterior group of muscles As the acute symptoms subside, the foot is held with a Gibney bandage When the peroneal tendon sheaths are involved the heel is held in valgus position by strips of adhesive tape 1 inch wide, which start just below the medial malleolus and run spirally around the lateral side of the heel and over the anterior part of the leg When the tendon sheath of the tibialis posterior muscle is involved the foot is held in supination and the adhesive strips are run from beneath the lateral malleolus over the inner side of the foot and spirally around to the outer side of the leg With this protection a moderate amount of weight bearing may be permitted

Bursitis Due to Chronic Infectious Arthritis. Bursitis of the foot may occur secondary to chronic infectious arthritis The bursa over the head of the first metatarsal bone is most frequently affected Another common site is the region of the insertion of the plantar aponeurosis into the calcaneus the bursitis here being associated with periostitis and exostosis It may also occur on the dorsum of the calcaneus anterior to the tendo achillis

Symptoms In the acute stage there may be redness and swelling over the site of the bursa In the region of the heel as well as of the great toe tenderness is the most constant finding Limp is usually the chief complaint

Treatment Rest in bed with elevation of the foot and the application of hot packs will usually result in a rapid disappearance of the acute symptoms With resumption of weight bearing the foot is protected against friction rub from the shoe It may be necessary to cut the counter of the shoe

Bursitis in connection with irritation on the plantar surface of the heel is relieved by means of a sponge rubber pad beneath the heel. At the same time, tension is taken off the plantar aponeurosis by putting the heel in varus and the anterior part of the foot in pronation With reestablishment of normal gait the bursitis will be cured provided the general arthritis subsides

Bursitis anterior to the insertion of the tendo achillis is treated by means of rest with the foot in plantarflexion and hot applications to the foot and lower part of the leg.

When the inflammation has been of long standing the bursa will be chronically inflamed and an exostosis of the calcaneus may be

present. In such cases the bursa and the exostosis are removed surgically through a lateral incision

DEFORMITIES DUE TO CHRONIC INFECTIOUS ARTHRITIS

Arthritis of the foot may result in pes valgoplanus or talipes equinus It may also bring about contracted toes or hallux valgus and exostoses

Pes Valgoplanus. *Symptoms* The symptoms and clinical signs of pes valgoplanus secondary to chronic infectious arthritis are the same as those for static pes valgoplanus except that they may be more severe and there may be more limitation of motion

Treatment In old people there may be a high degree of pes valgoplanus without pain when there is no decompensation of function For this reason corrective measures are not necessary In a young adult the deformity must be corrected

The infectious process must first have been quiescent for at least six months before active treatment is begun The foot is manipulated and the articulations are freed a cast is applied with the foot in the midposition Walking may be started in the cast with a walking caliper attached After the cast is removed an Unna paste boot is utilized for two weeks and the foot is further protected with a stiff shanked shoe. Exercise is gradually started using the corrective shoe as described under Pes Valgoplanus Rarely there is a persistence of pain due to arthritic changes in the talocalcaneal articulation this requires arthrodesis In this case one must consider the advisability of also fusing the calcaneocuboid and talonavicular articulations

Talipes Equinus. *Treatment* If the talipes equinus is due to a simple contracture without destruction of the talocrural articulation, the tendo achillis may be stretched by means of the Haglund manipulative board If the tendo achillis is persistent in its contracture, subcutaneous tendon lengthening may be indicated Where there is destruction of the articular surface, the problem is extremely difficult Every attempt should be made to hold the foot in the midposition and to protect the ankle joint until the inflammation has subsided This can be done by a padded plaster of paris cast Form fitting leather braces reinforced with steel are worn to protect the ankle further Walking is facilitated by raising the heel of the shoe

If the ankle remains painful in spite of all conservative treatment it will be necessary to fuse the talocrural articulation in order to obtain relief The technic is the same as that described for Tuberculosis of the Talocrural Articulation

Contracted Toes Contracted toes as a result of chronic infectious arthritis may persist after the chronic infectious process has subsided entirely Subluxations occur at the metatarsophalangeal articulation (Fig 147)

Treatment Tenotomies are performed when necessary The deformity is obliterated by manipulation and the corrected position is held with a plaster of paris cast. Weight bearing is permitted as soon as the pain has subsided

Preliminary correction by means of the corrective shoe is carried out before the operation, and in many cases satisfactory correction can be obtained without surgical intervention In severe contrac



Fig. 147 Contracted toes secondary to chronic infectious arthritis Note the subluxation at the metatarsal phalangeal articulation

tures in senile patients, symptomatic relief may be obtained by the use of pads just posterior to the elevated joint of the toe, to prevent friction rub of the dorsum of the toe against the shoe A white felt pad ⅜ inch thick, is placed over the dorsum of the proximal phalanx so that the pressure will strike against the felt and the projecting angle of the toe will no longer rub against the shoe If the toe is protected in this manner and the corrective shoe is worn there will be a tendency for gradual elongation of the toe and ultimate correction of the deformity

In some instances the pain is due to an irritated callus on the distal end of the plantar surface of the toe In such cases the symptoms are relieved by fitting a felt pad, about ⅜ inch thick and ½ inch square, on the flexor surface of the toe. This not only removes the pressure from the tender callus but also exerts a force to elongate the contracted toe and thus prevents friction rub

Hallux Valgus. In addition to the hallux valgus deformity and the projection of the head of the first metatarsal bone, exostoses will be present (Fig 148) These exostoses may be so large that they limit motion or there may be an actual fixation of the metatarso-phalangeal articulation thus causing hallux rigidus

Treatment In the treatment of the arthritis in the metatarso-phalangeal articulations rest is indicated The joint may be relieved of weight bearing by a felt pad in the region of the longitudinal arch with an inclined plane to throw the weight on the outside of the foot At the same time an anterior transverse felt pad is applied immediately posterior to the head of the first metatarsal bone This



Fig 148 Hallux valgus secondary to chronic infectious arthritis

pad in conjunction with the longitudinal pad supports the shaft of the first metatarsal bone and thus prevents pressure at the articulation To relieve pressure of the shoe over this area the shoe may be stretched to allow space for the enlarged articulation in some cases it may be necessary to split the shoe

While the inflammation is abating and during the subacute stage adequate relief is occasionally obtained by covering the inflamed part of the articulation with a thin form fitting rubber appliance. In those cases where there is an actual exostosis projecting upward and laterally rub against the shoe is prevented by a felt pad placed proximal to the projection

Surgical correction of hallux valgus and hallux rigidus secondary to chronic infectious arthritis of the foot is the same as described previously for these deformities from other causes

Other Deformities Due to Chronic Infectious Arthritis. Hammer toe secondary to chronic infectious arthritis is treated as described for that deformity due to other causes The extremely contracted fifth toe, secondary to chronic infectious arthritis, may be corrected by the operation described for digiti quinti varus, or it may be amputated, inasmuch as correction by conservative measures is difficult and the loss of this toe causes no functional disturbance

Dorsal exostoses at the tarsometatarsal articulation may be removed with an osteotome or thin chisel Adequate exposure is ob-



Fig. 149 Exostoses on plantar surface of the great toe secondary to chronic infectious arthritis

tained through a small incision After suture of the skin the foot must be kept quiet either by fixation of the part or by rest in bed until healed

Exostoses secondary to chronic infectious arthritis occur on the plantar surface of the great toe and give rise to painful pressure points that are covered with callus Removal of the callus and the underlying exostosis may be executed through a small incision under local anesthesia They are removed easily with a thin chisel, and the bone is curetted until the surface is smooth Protection of the wound must be carried out until it is healed completely (Fig 149)

Exostoses as the result of chronic infectious arthritis may occur on the calcaneus These sometimes assume the form of large plantar

spurs or may be seen in the roentgenogram as excessive growth formations in the region of the insertion of the tendo achillis Pads in the shoe give relief A sponge rubber pad in the heel of the shoe affords some protection against irritation in the region of the overgrowth Corrections may be applied to the outside of the shoe; the heel is brought into varus and a comma-shaped transverse bar with a definite inclined plane is used This tends to relieve the tension on the plantar aponeurosis and the irritation in the region of the plantar spur With the subsidence of the inflammation in the region of the exostosis, the pain disappears

There may be exostoses, as seen by roentgenogram without symptoms If no satisfactory response to conservative treatment can be obtained, the exostoses should be removed under general anesthesia and in a bloodless field The exostosis is exposed and removed, the bony surface is made smooth and the wound is closed

REFERENCES

Calve, J Treatment of Tuberculosis of the Ankle in the Adult J Bone & Joint Surg., *4* 53 1922

Carrell B., and Childress, H M Osteochondritis Dissecans of a Metatarsal Head J Bone & Joint Surg., *22*·442, 1940

Duncan, G G Diseases of Metabolism 2d ed Philadelphia, W B Saunders Company 1947

Gaenslen F J Split Heel Approach in Osteomyelitis of Os Calcis J Bone & Joint Surg., *13* 759 1931

Hanson, R. The Treatment of Tuberculosis of the Talocrural and Talocalcaneal Joints Acta orthop Scandinav., *6* 285 1935

Hench P S Diagnosis and Treatment of Gout and Gouty Arthritis J.A.M.A., *116*·453 1941

Kelly R P Osteomyelitis. J Bone & Joint Surg *28*·681 1946

Key J A The Treatment of Tabetic Arthropathies (Charcot s Joint) Urol & Cutan Rev., *49* 161 1945

Steindler A The Tabetic Arthropathies J.A.M.A., *96* 250 19 1

Thompson, T C The Management of the Painful Foot in Arthritis M Clin North America, *21* 1785 1937

23

INFECTIONS OF THE FOOT

The thick sole of the foot and the leather shoe act as protective mechanisms in preventing frequent occurrence of infections in the foot Most infections occur secondary to some previous disturbance such as a callus corn or blister Abrasions of the skin and penetrating wounds although relatively rare, do occur Crushing injuries, as described under compound fractures are occasionally encountered

SUPERFICIAL INFECTIONS

Superficial infections of the skin are usually encountered on the dorsum of the foot, they most frequently occur secondary to an abrasion or blister The friction rub of a shoe may give rise to a blister usually in the region of the dorsum of the great toe or in the region of the posterior surface of the heel These blisters may rupture and become infected

Symptoms. The symptoms are pain redness swelling and local heat, with spreading of the inflammation proximally When the area about the great toe is involved, the infection tends to spread along the loose areolar tissue on the dorsum of the foot which becomes swollen and edematous In the region of the heel the infection drains through the popliteal lymph nodes which may be tender quite early If the infection is due to a streptococcus lymphangitis may occur with relatively little local redness and swelling Spread of the infection is rapid The inflammatory reaction in the region of the blister spreads and extends upward the temperature rises rapidly and may be associated with chill The glands in the popliteal space and in the inguinal region are enlarged and tender to palpation

Treatment In the presence of a blister the skin in the area is washed thoroughly with soap and water and covered with a sterile dressing. A blister so large that there is danger of rupture is cleansed thoroughly and aspirated If the blister has ruptured it is cleansed

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REFERENCES

Calve, J Treatment of Tuberculosis of the Ankle in the Adult. J Bone & Joint Surg., 4 53 1922.

Carrell, B., and Childress, H M Osteochondritis Dissecans of a Metatarsal Head J Bone & Joint Surg., 22-442, 1940

Duncan G G Diseases of Metabolism 2d ed Philadelphia, W B Saunders Company 1947

Gaenslen F J Split Heel Approach in Osteomyelitis of Os Calcis J Bone & Joint Surg., 13 759 1931

Hanson R The Treatment of Tuberculosis of the Talocrural and Talocalcaneal Joints Acta orthop Scandinav., 6 285 1935

Hench P S Diagnosis and Treatment of Gout and Gouty Arthritis J.A.M.A., 116-453 1941

Kelly R P Osteomyelitis J Bone & Joint Surg., 28-681 1946

Key J A. The Treatment of Tabetic Arthropathies (Charcot s Joint) Urol & Cutan Rev 49 161 1945

Steindler A The Tabetic Arthropathies J.A.M.A., 96.250 19 1

Thompson T C The Management of the Painful Foot in Arthritis M Clin North America 21 1785 1937

23

INFECTIONS OF THE FOOT

The thick sole of the foot and the leather shoe act as protective mechanisms in preventing frequent occurrence of infections in the foot. Most infections occur secondary to some previous disturbance such as a callus corn or blister Abrasions of the skin and penetrating wounds, although relatively rare, do occur Crushing injuries as described under compound fractures are occasionally encountered.

SUPERFICIAL INFECTIONS

Superficial infections of the skin are usually encountered on the dorsum of the foot they most frequently occur secondary to an abrasion or blister The friction rub of a shoe may give rise to a blister, usually in the region of the dorsum of the great toe or in the region of the posterior surface of the heel These blisters may rupture and become infected.

Symptoms. The symptoms are pain redness swelling and local heat with spreading of the inflammation proximally When the area about the great toe is involved the infection tends to spread along the loose areolar tissue on the dorsum of the foot which becomes swollen and edematous In the region of the heel the infection drains through the popliteal lymph nodes which may be tender quite early If the infection is due to a streptococcus lymphangitis may occur with relatively little local redness and swelling Spread of the infection is rapid The inflammatory reaction in the region of the blister spreads and extends upward the temperature rises rapidly and may be associated with chill The glands in the popliteal space and in the inguinal region are enlarged and tender to palpation

Treatment In the presence of a blister the skin in the area is washed thoroughly with soap and water and covered with a sterile dressing A blister so large that there is danger of rupture is cleansed thoroughly and aspirated If the blister has ruptured, it is cleansed

thoroughly and a sterile dressing is applied. The blister is left alone, neither antiseptics nor salves being used

In the presence of an infection in the foot immediate rest in bed is indicated Infected material is taken from the wound for cultures and the administration of appropriate chemotherapy or antibiotics is begun The wound is cleansed gently with zephiran chloride or soap and water for ten minutes using sterile gauze or cotton and this is followed by the application of hot packs and elevation of the limb Sterile dressings are applied to the infected blebs, and the limb is wrapped in a large sterile towel. The entire limb is included to a point well above the knee The limb is then put into a large electric baker or two infra-red lamps that can be controlled easily are directed on the moist pack. Sterile moisture is added to the dressing without disturbing the patient

The hot dressings are continued day and night the dressing need be changed only once daily or even less frequently under aseptic surgical conditions The hot packs are continued until the infection is under control and the local inflammation has abated This is followed by the intermittent application of sterile soaks The sterile moist dressings and heat are applied for a period of about an hour three times daily In this way the skin has a chance to recover in the intervals and maceration is avoided

Rest for the limb is important. In some instances this is best accomplished by a cast and dressings carried out through an opening in the cast or a splint may be used This also makes it easier to elevate the limb

In addition to rest and the local application of moist heat the intake and output of fluid are measured to be certain that an adequate amount is obtained. Sufficient fluids will be obtained if the daily output of urine is 1500 cc.

With the subsidence of the inflammation sterile dressings are continued until the wound is entirely healed protection is then carried out against further friction rub from the shoe.

PARONYCHIA

Paronychia is an infection encircling the nail and causing inflammation of the adjacent tissue It usually occurs secondary to an ingrowing toenail, but may be the result of trauma to the toe Infection is frequently carried in by septic attempts to remove the part of the nail that projects into the tissues. An abrasion of the tissue with contaminated scissors is also frequently a cause The tissue at the side of the nail becomes infected and pus may form

between the nail and this tissue as well as under the corner of the nail

Symptoms The symptoms are pain swelling and redness along the lateral and distal margins of the nail The infection spreads to encircle the nail bed The pain is throbbing sometimes extreme, and is increased by pressure of the shoe

Treatment. Prophylactic treatment consists in the proper care of the ingrown toenail (see p 360)

The first step in the treatment of paronychia is to cleanse the foot thoroughly with soap and water without irritating the wound—that is by gentle and repeated washings with sterile cotton and soap This is frequently sufficient to permit drainage of the pus from the margin

At times it may be necessary to remove a corner of the nail that projects into the tissue This is done with a nail forceps which cuts the nail close to the lateral margin for about ¼ inch The nail is then rolled free and removed from beneath the epidermis. This is followed by the application of sterile dressings and heat and elevation of the foot. Repeated washings with soap and water for a period of ten minutes are carried out each day at the time the wound is dressed The application of sterile moist dressings with heat periodically for an hour three to four times a day is continued until all signs of infection have disappeared. Treatment then resolves itself into prevention of the ingrown toenail Rest, elevation of the foot and local heat are important in the treatment of infections of the foot

If the infection does not subside the hot dressings are continued twice a day The infection may spread under the nail in which case the eponychium is dissected on each side of the nail bed and a nail cutting forceps is used to remove the proximal third Hot applications are again administered with the foot elevated, and continued until the infection subsides

If the wound does not heal one must consider the possibility of diabetes, syphilis a secondary infection or dermatomycosis Smears and cultures are made to ascertain the type of infection particularly if incision and drainage were necessary

LYMPHANGITIS

A peripheral infection around the nail or in the side of the toe may be caused by an ingrown toenail an abrasion a perforation or an ulceration due to ringworm or gangrene. The resistance of the skin is lowered so that either streptococcus or staphylococcus may

bring about a serious infection Depending on the virulence of the bacteria and the resistance of the patient the infection tends to spread and it may take one of two courses or a combination of both it may develop along the fascial spaces or spread along the lymphatic system The infection first spreads along the dorsum of the toes to the dorsum of the foot, involving the subcutaneous fascial space First it appears as cellulitis, and later it localizes The infection on the dorsum of the foot is usually limited to the region above the involved toe later, as the infection spreads the entire dorsum of the foot becomes involved

Symptoms Usually if treatment is instituted, the infection is *limited to this stage. Occasionally however the infection spreads* owing to lowered resistance or to the virulence of the infection itself Local resistance may be impaired by unwise surgery The infection then extends along the lymphatic vessels and gives rise to swelling of the lymph nodes and, in some cases, to inflammation of the lymph channels When the lymph channels become inflamed they can be seen as red streaks along the course of the veins and palpated as firm tubes beneath the skin The swollen lymph nodes are tender to touch. The infection sometimes results in an abscess in the nodes The patient shows malaise and signs of generalized infection the fever is high and there is a leukocytosis with a relative increase of the polymorphonuclear cells At first the resistance may be so low that the white count is only moderately high or it may even be less than normal then as the infection tends to localize, the leukocyte count may increase. In severe infections the urine will frequently show albumin and casts

Treatment. Treatment of the lymphangitis may be conservative until the infection has been localized. Fluids are forced as much as possible is taken by mouth and hypodermoclysis and intravenous *methods are used to assure an adequate supply* The usual requirement of an adult with infection is enough fluid so that the output of urine will be about 1500 cc. The foot is elevated and hot packs are applied from the foot up to and including the groin If necessary the pain is controlled by opiates Rest is imperative. Movement will have a tendency to break down the leukocytic wall and overzealous treatment of the wound with instruments and strong antiseptics interferes with the normal process of the resistant forces to wall off the infection Either chemotherapy or antibiotics or both are administered immediately When the infection spreads in spite of elevation and rest roentgen treatment has been found of value

With the subsidence of the lymphangitis and the disappearance

of tenderness over the lymph nodes in the popliteal and inguinal spaces, the infection in the foot becomes walled off, forming an abscess or it subsides entirely With abscess formation it is necessary to evacuate the pus and continue with the hot packs If the abscess is localized to the toe, this is done by a small incision on the lateral side of the toe. The incision is made under general anesthesia with a minimum amount of trauma To prevent immediate closure of the wound a petrolatum pack may be left in it for twenty four hours. This is then gently removed, and hot moist dressings are continued until the acute inflammation abates The moist packs are then continued twice daily The limb is kept elevated throughout treatment

Lymphangitis may develop in a similar manner from an infection in a blister at the heel The blister usually occurs as a result of friction rub from the shoe; this is followed by a secondary infection either staphylococcal or streptococcal with a sudden appearance of symptoms The first manifestation of the spread of the infection may be a lymphadenitis in the popliteal space and the lymphangitis may develop later At times, the condition is limited to the initial infection and a lymphadenitis The infection may localize in the popliteal lymph nodes and form an abscess in this area.

Occasionally it may be necessary to make an incision under general anesthesia to evacuate the pus in the popliteal space, but this must be done only after the infection is well walled off It should never be done in the presence of lymphangitis

In most cases, however the lymphadenitis will subside on conservative treatment consisting in rest, elevation of the limb, continued hot packs and sulfa drugs or penicillin In every case the wound must be cleansed without irritation and guarded against secondary infection by means of aseptic dressings

INFECTIONS OF THE TENDON SHEATHS

Pyogenic infections of the tendon sheaths are rare. Occasionally they do occur in the flexor tendon sheaths of the toes, usually in connection with a spreading infection of the toes If the tendon sheath is infected the infection will spread along the entire space Care should be exerted in opening a sheath not to divide the mesentery of the tendon and thus destroy the blood supply

INFECTIONS IN THE DEEP PLANTAR FASCIAL SPACES

Infection of the nail of a toe may spread to the dorsal fascial space Infection of the toe particularly on the plantar surface, may

cause a secondary infection of the superficial plantar fascial space, which is the same as the first plantar fascial space of the central compartment (See anatomic description on page 9) Interdigital infection if it spreads to a fascial space, will follow the lumbrical muscles to involve the second and third fascial spaces of the central compartment An infection of the dorsal subcutaneous space likewise will follow the course of the lumbrical muscles to infect the *second and third spaces of the central compartment* Since the dorsal subcutaneous space and the middle two spaces of the central compartment are connected, an infection of the second and third fascial spaces may result in a swelling on the dorsum of the foot In a penetrating wound the infection may be carried directly to the central compartment

Symptoms. When the infection spreads to the plantar fascial spaces there is swelling of the foot The swelling in the dorsal subcutaneous space is apparent There is tenderness on deep pressure over the plantar surface and fever and leukocytosis signs of the generalized infection are present Usually there is a cellulitis accompanied by swelling redness and induration This may be followed by localization of the infection in the deep fascial space and the formation of pus

Treatment When the dorsal subcutaneous space is involved secondary to a superficial infection around the nail treatment directed against the infected area results in a subsidence of the inflammatory reaction in the dorsal fascial space When the superficial plantar fascial space is involved either as the result of a penetrating wound or secondary to an infection of the toe, the primary wound should be thoroughly cleansed and conservative measures carried out

In every case the original site of the infection should be ascertained and thoroughly cleansed and conservative treatment instituted This would include rest for the foot The limb should be elevated and hot sterile, moist dressings should be applied from the toes to well above the knee Chemotherapy or antibiotics should also be administered Drainage is necessary only when there is localization of pus in a fascial space

If the superficial plantar fascial space contains pus any drainage required can be accomplished through a medial incision along the plantar border of the first metatarsal bone under tourniquet A curved forceps or blunt scissors is inserted between the metatarsal bone and the plantar muscles staying close to the bone with the forceps The space can be entered and opening the forceps or scissors

will permit drainage of the abscess in this fascial space without an incision on the plantar surface of the foot.

The second and third deep plantar fascial spaces of the central compartment may be drained through the same type of incision. In no instance should these spaces be drained from the dorsum of the foot. A drain should never be passed from the dorsum of the foot through to the plantar surface.

In many instances the infection abates so that a low grade chronic infection persists with edema of the foot, ankle and even the leg. In this type of case rest is obtained by a plaster of paris cast. The foot can be elevated to reestablish circulation. As the swelling decreases, the cast is renewed. The wound may then be dressed through an opening in the cast. Dressing of the wound consists in cleansing it with soap and water and covering it with a sterile dressing or a petrolatum pack. Compression is applied over the opening in the cast to prevent swelling of the area around the wound. The cast may be replaced by an Unna paste boot.

When the infection has subsided, it is necessary to reestablish normal function of the foot. In some cases a walking caliper may be applied to the cast, to start weight bearing, or the Unna paste boot and a normal shoe may be utilized. After the boot is removed physical therapy consisting in heat, massage and active motion is carried out along with reeducation to a normal gait.

INFECTED BURSAE

The bursae most commonly infected are the adventitious bursae secondary to a corn or plantar callus and the bursa at the head of the first metatarsal bone.

Adventitious Bursa Secondary to a Corn. *Symptoms.* A small bursa that forms between a corn and the projection of bone that causes the corn is usually infected as the result of improper trimming of the corn. This infected bursa becomes inflamed. The surrounding area may first become swollen and red and the infection may gradually localize and form pus in the bursa. The pain is excruciating on pressure.

Treatment. Treatment consists in cleansing the area with repeated washings with soap and water for ten minutes. Drainage is then accomplished by trimming the corn with a sterilized instrument; this can usually be done without an anesthetic. The corn is pared until the pus exudes. Once the pus has been evacuated drainage usually continues without any further assistance save the use of

hot applications Elevation of the foot and hot applications are carried out until the inflammation subsides Later it is sufficient and more practical to use hot packs for periods of one to two hours at a time, two to four times a day The area is covered with a sterile dressing The infected corn is observed and dressed under aseptic conditions until the inflammatory reaction has entirely subsided.

Adventitious Bursa Secondary to a Plantar Callus. *Symptoms* Occasionally an adventitious bursa occurs between a callus and the underlying bone. The callus may become infected and may also involve the bursa underneath The result is an acutely painful area particularly on weight bearing or pressure

Treatment Drainage of the infected bursa or of the abscess lying underneath the callus is accomplished directly through the callus itself after careful cleansing After washing thoroughly with soap and water for ten minutes, the callus is pared, layer by layer with a scalpel until the pus exudes usually no anesthetic is necessary Adequate drainage is obtained through such an opening. There is practically no tendency toward closure because of the thickened wall of the callus until the infection has subsided Rest moist bone packs and elevation of the limb are indicated until there is no drainage. The sole is washed with soap and water daily and sterile dressings are applied. The callus is trimmed, and weight bearing is removed from this area The final treatment consists in removal of the factor causative of the callus

Bursa at the Head of the First Metatarsal Bone. *Symptoms* The bursa at the head of the first metatarsal bone may be inflamed for a long period without becoming infected Infection usually enters through the skin In some cases the bursal sac ruptures to form a sinus, secondary infection then takes place. In other cases the skin is calloused over the bursal area and improper trimming of this callus results in infection of the bursa In most cases therefore the infected bursa is associated with sinus and the sinus usually permits adequate drainage, particularly since the bursal cavity may be obliterated by means of compression dressing

Treatment Treatment consists in elevation of the foot and in the application of moist heat This is usually sufficient to clear up the infection The heat is continued until all the inflammation has disappeared.

It is well to remember that no surgical procedure for the correction of the inflamed bursa or the underlying cause, the hallux valgus should be carried out until a period of at least six months has elapsed after the presence of an acute or septic infection in the

bursa since there is danger that the latent infection will flare up and spread through the operated area This principle may be modified in selected cases with the use of antibiotics preoperatively and postoperatively

REFERENCES

Callander C. L. Surgical Anatomy 2d ed revised Philadelphia, W B Saunders Company 1948

Grodinsky M A Study of the Fascial Spaces of the Foot and Their Bearing on Infections Surg., Gynec & Obst., 49 737 1929 A Study of the Tendon Sheaths of the Foot and Their Relation to Infection Surg., Gynec. & Obst., 51 460 1930 Foot Infections of Peridigital Origin. Ann Surg., 94 274 1931

Kanavel, A. B Infections of the Hand 7th ed. Philadelphia, Lea & Febiger 1939

Koch S L. Inflamed and Injured Tissues Need Rest. Surg., Gynec & Obst., 82 749 1946

24

TUMORS OF THE FOOT

GANGLION

A ganglion may occur on the foot usually on the dorsum in connection with the extensor tendons of the toe; it rarely causes serious



Fig. 150 Ganglia of the feet

trouble It arises from the joint capsule or from the sheaths of the extensor tendons and consists of multiple cystic areas which may become confluent to form one large cyst filled with a thick, yellowish gelatinous substance (Fig 150)

Treatment Usually a ganglion disappears when pressure over the area is removed and the foot strain is relieved One may occasionally persist, however In most cases a ganglion does not give rise to any disturbance in function Sometimes it is desirable to remove it This is done in a bloodless field under general anesthesia the entire cystic area is removed by careful dissection

LIPOMA

Lipoma rarely occurs in the foot, if one does not include swelling of the adipose tissue beneath the malleoli The true lipoma occurs under the skin of the dorsum of the foot It is not painful but on pressure will give rise to slight discomfort. It is of no clinical significance unless it becomes large and presses on a nerve Occasionally the tumor will grow along the tendon sheath or it may penetrate through from the dorsum of the foot to the plantar surface.

Treatment For the small lipoma, without symptoms no treatment is necessary When it gives rise to symptoms it should be removed by careful dissection, for in the event of incomplete removal it will recur

OSTEOCHONDROMA

Osteochondroma may involve the metatarsus or the phalanges of the toes. The tumor grows by expansion of the cortex, forming an enlargement along the shaft. Occasionally it will result in pathologic fracture. The outer surface of the tumor is smooth and pushes the soft tissues before it. It may increase in size to such an extent that it gives rise to symptoms of pressure and interferes, to some extent with normal use of the foot The roentgenogram shows an expanded rarefaction of the bone Osteochondroma occurs on the posterior surface of the calcaneus It may be associated with osteochondromata in other bones (Fig. 151)

Treatment. The tumor should be removed This is a simple matter when the chondroma is pedunculated When it involves the entire cortex of the shaft it can be removed by curettement the tumor tissue being softer than the normal bone When the tumor involves the cortex so that there is a fracture or danger of one it may be advisable to use bone grafts after removal.

OSTEOMA

Osteoma occurs on both the plantar and dorsal surfaces of the foot On the plantar surface large exostoses may be seen growing from the talus from the cuneiform bones or from the base of the



Fig 151 Osteochondroma of the foot.



Fig 152 Osteoma of the fibula

first metatarsal bone. Large exostoses are also seen growing on the plantar surfaces of the calcaneus and first metatarsal bone. These projections may be large enough to cause pressure on the skin and give rise to acute pain. Sometimes they may be large, as seen by roentgenogram, but give rise to no symptoms (Fig. 152).

When an osteoma is so large that it projects and causes pressure and friction rub, it may be necessary to remove it surgically.

BONE CYST

Bone cysts have been observed in the talus and in the calcaneus. In most cases they are symptom free and are usually observed in

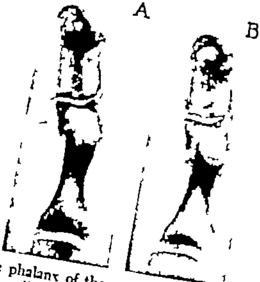


Fig. 153. Cyst of the phalanx of the second toe. A, Fracture through the cyst; B, callus denotes healing of the fracture.

the roentgenograms (Fig. 153). At times they give rise to pain and swelling following slight trauma. Single cysts have been observed over long periods without giving rise to any disturbance. One case of bone cyst at the distal end of the proximal phalanx showed a pathologic fracture. There was evidence of foot strain of the anterior part of the foot.

Treatment. The treatment, when indicated, consists in curettement of the cyst and in filling the cavity with bone chips. If a cyst in the tarsal bones is part of a generalized condition such as fibrocystic disease, the possibility of parathyroid tumor should be investigated. One patient with a phalangeal cyst was treated by a cast followed by the corrective shoe, and the symptoms were relieved.

GIANT-CELL TUMOR

Giant-cell tumor occurs rarely It has been observed in the calcaneus in the talus and in the distal end of a metatarsal bone (Fig. 154) Treatment consists in removal by curettement. This may be followed by filling the cavity with multiple chip grafts



Fig. 154 Giant-celled tumor of the second metatarsal bone

SUBUNGUAL EXOSTOSIS

Subungual exostoses usually occur under the nail of the great toe. The protrusion of bone causes pain and the growth may gradually increase in size and give rise to chronic inflammation of the nail bed (Fig. 155)

Treatment consists in removal of the exostosis, usually by a mid line incision through the nail and nail bed exposing the exostosis with a minimum amount of destruction to the nail bed. A small thin narrow osteotome is used to remove the exostosis

FIBROMA

Fibroma of the foot may arise from the skin and subcutaneous tissue or from the flexor tendon sheaths It is a slow-growing, pain less growth. On the surface it is made up of hard nodules that project and form a wartlike growth. The tumor is firm and may be about the size of a hazelnut occasionally it grows to much larger dimensions A condition similar to Dupuytren s contraction of the palmar fascia in the hand may involve the plantar fascia The two are frequently associated

Treatment Since this is a benign tumor it does not require

treatment. When it has grown to a large size however it is best to remove it surgically

FIBROMA MOLLUSCUM
(*Von Recklinghausen s Disease*)

Fibroma molluscum is a small tumor about the size of a pea which occurs on the plantar surface of the foot It is usually multiple and consists of small soft round tumors that show a bluish color



Fig 155 Subungual exostosis.

through the skin It is part of a generalized disease, and the tumors involve the peripheral nerves

When the tumors attain a size that causes mechanical interference, surgical removal is indicated.

XANTHOMA

Xanthoma in the foot is difficult to diagnose except after surgical exposure The tumor extends along the tendon sheath but does not penetrate the joint capsule It is benign a section will show the characteristic large, polyhedral cell which contains xanthophyll from which the tumor obtains its color (Fig 156) I have observed one on the great toe which involved the digital nerves The symptoms were pain and paresthesia The pain was present at first only on use of the great toe in walking later it became constant

Occasionally a generalized xanthomatosis with hypercholesterolemia may involve the foot (Fig 157) The tumors are painless



Fig 156 Photomicrograph of xanthoma of tendon sheath characterized by fibrous tissue framework, which contains nests of pale staining foam cells (*A*) and foreign body type giant cells (*B*) (Courtesy of Dr Lloyd H Jergesen)

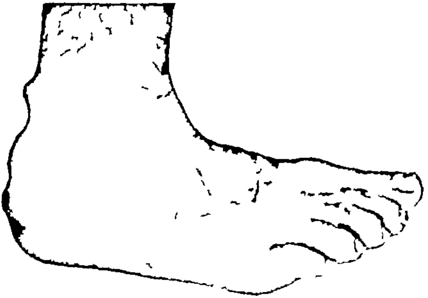


Fig 157 Xanthoma of the tendo achillis in a case of generalized xanthomatosis

and vary markedly in their rate of growth Interference with function usually leads the patient to seek medical advice.

Treatment Small xanthomata are said to disappear under a low fat diet. In some cases there is a concomitant diabetes, and control of the diabetes is sometimes sufficient treatment for a small xanthoma When the tumor masses interfere with function, it is necessary to remove them by careful sharp-knife dissection in a bloodless field The tumor will recur unless removed entirely

EPIDERMOID CYST

Epidermoid cysts have been observed on the plantar surface of the foot They are small cysts within the skin, the cavity is filled with cholesterol and the wall is lined with epithelium These cysts are caused by the presence of skin tissue in the subcutaneous area The skin tissue grows and forms a cyst

Treatment consists in removal of the entire cyst by sharp-knife dissection

CALCINOSIS OF THE SKIN

Calcareous deposits in the skin and subcutaneous tissue, without apparent cause, rarely occur in the foot The condition is usually associated with calcification of the skin in the palmar surface of the hand The thickened nodules may be palpated beneath the skin and the deposits show a shadow in the roentgenogram

There is no known treatment for this unusual condition

ANGIOMA

An angioma is a vascular tumor, usually called a birthmark or nevus, which is characterized by a reddish discoloration and slight raise of the skin It is due to an enlargement of the superficial veins, and pulsation may be felt over the tumor When it is on the plantar surface, pressure may cause pain. There are three types of angioma the flat telangiectatic type, nevus flammeus or port-wine mark, the hypertrophic or protruding type; and the cavernous type. The last involves both arteries and veins. All angiomata may gradually increase in size Multiple cavernous angiomata are due to anastomoses of an artery and vein, and the veins carry arterial blood

Treatment For the hypertrophic and cavernous angiomata radium is the treatment of choice For the port wine mark, the only satisfactory and safe method of treatment at present is grenz rays However in the usual case of port wine mark there is no indication for any treatment Injection methods have been used in

the treatment of hypertrophic birthmarks, but the pain and danger of embolism and uncontrollable hemorrhage are definite contraindications.

SUBUNGUAL GLOMUS TUMOR

A glomus tumor arises from the nail bed underneath the nail. This is usually a small tumor characterized by a mass of blood vessels. Trauma to the nail may precede the appearance of the tumor. In the presence of the tumor trauma to the nail may cause



Fig. 158. Photomicrograph of section through neurinoma showing whorl formation, palisading of nuclei and proliferation about nerve axons.

an increase in size and result in pressure on the nerves. At first the pain is in the toe but it may radiate along the entire extremity. The tumor can be seen as a slight discoloration underneath the nail. As it grows the symptoms increase. The pain may come on in attacks and then decline after a period of time; it is usually worse after exposure to cold.

Glomus tumors are an overgrowth of the glomus bodies which occur normally in the skin and regulate circulation and heat. They are made up of neural, muscular and arterial tissues. Microscopically one observes a large number of thin walled vessels with narrow

lumina, surrounded by large cuboid-shaped cells Between these large cells are collagenous filaments In cases of attacks of pain in the foot for which the explanation is not evident this rare tumor must be considered.

Treatment Surgical removal of the tumor results in relief of symptoms.

NEURINOMA

A neurinoma arises in one of the plantar nerves of the foot. There is a fibrous tissue capsule enclosing the proliferating Schwann sheath

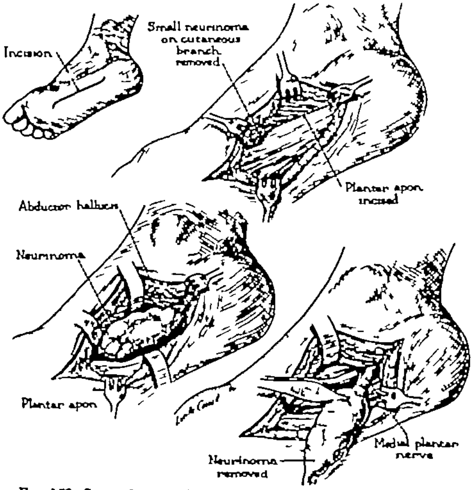


Fig. 159 Surgical removal of neurinoma of medial plantar nerve.

cells These cells have large vesicular oval nuclei and are arranged in large concentric whorls (Fig 158)

The larger nerve trunks are affected. Plantar nerve involvement is rare. The tumor is encapsulated slow growing and is found as firm or soft masses attached to the nerve trunk. Pressure elicits pain

There is a tendency to local recurrence, usually proximal to the original tumor

Surgical excision is the treatment of choice (Fig 159)

SARCOMA

Melanotic sarcoma occurs in the foot It usually begins as a mole and may remain unchanged for years and then suddenly undergo malignant change. Such a pigmented mole must be approached with caution It will undergo degeneration which results in ulceration and



Fig 160 Photomicrograph of malignant melanoma of toe (Hutchinson s melanotic whitlow) characterized by great variability of both cell picture and architecural arrangement malignant cells may or may not be pigmented Mitoses usually are abundant *A*, Melanin-laden neoplastic cells *B* non-pigmented neoplastic cells

gives the appearance of gangrene The melanotic sarcoma is extremely malignant and metastasizes early (Fig. 160)

Treatment. Small pigmented moles respond well to radium therapy huge doses of filtered radium apparently preventing the occurrence of metastatic dissemination Pigmentation may be visible after radium therapy but should not occasion apprehension When the pigmented mole ulcerates a specimen is taken for biopsy using a tourniquet If the frozen section shows sarcoma amputation should be carried out

Myelogenous and periosteal sarcomata as well as Ewing tumors

have been observed in the foot but are rare They tend to metastasize The treatment required is removal by radical operation

METASTATIC TUMORS

Metastatic tumors occasionally involve the foot and ankle (Fig 161), although they are more frequently located in the middle of the shaft of long bones The process is usually destructive and occurs more frequently in older people. Sudden and severe pain characterizes the onset



Fig. 161 Metastases in tibia from carcinoma of the breast

Treatment in most cases is best effected by x ray therapy In some cases excision for diagnosis or to prevent ulceration may be necessary

REFERENCES

Campbell W C. *Osteogenic Sarcoma, with Report of Cases* Am J Surg., 20 575 1933

Friedman M S Xanthoma of the Achilles Tendon J Bone & Joint Surg., 29-760 1947

Bergstrand, H Multiple Glomic Tumors Am J Cancer 29-470 1937

Hauser E. D W Neurofibroma (Neurinoma) of the Foot. J.A.M.A., 121 1217 1943

Kahn M., and Cohn, L. C Diagnosis and Treatment of Bone Lesions of the Hand and Foot, with Special Reference to Bone Tumors Radiology 8 289 1927

Loeb M J Trauma and Glomus Tumors Relationship with Report of a Case. Industrial Med., *10* 208, 1941

Mason, M L Tumors of the Hand Surg., Gynec. & Obst., *64* 129 1937

Pardo-Castello V Diseases of the Nails Springfield, Ill., Charles C Thomas, 1936

Young, F., and Harris, C. T Complete Excision and Reconstruction of Both Achilles Tendons for Giant Cell Xanthoma Surg., Gynec. & Obst 61-662, 1935

25

DISEASES OF THE SKIN AND NAILS

HYPERHIDROSIS

Etiology The skin of the sole of the foot is richly supplied with sweat glands Excessive perspiration may be caused by exercise, too warm a stocking or too heavy a shoe, venous congestion vasomotor disturbances, or foot strain

Symptoms Perspiration out of proportion to the body temperature is considered to be hyperhidrosis An offensive odor may be present and is termed 'bromidrosis'

The persistence of excessive perspiration may lead to maceration of the skin and, in hot weather a form of eczema may develop Blisters may appear on the sole of the foot, and sometimes there is peeling of the skin between the toes

Treatment Hygienic measures are essential The feet should be washed at least once daily in cool water, dried thoroughly and sprinkled with powder The hose should be changed two or three times a day if necessary

Contrast foot baths at night help to overcome circulatory disturbance The feet are submerged one minute in cold water and then one minute in warm water repeating about fifteen times, followed by an alcohol massage to toughen the skin If the skin is thin and sensitive, a 10 or 20 per cent formalin solution may be used.

Foot strain or pes valgoplanus if present should of course, be treated.

BROMIDROSIS

Perspiration at times undergoes decomposition and the oil secreted from the sebaceous glands deteriorates into amino acids which have an offensive odor It is also probable that certain types of bacteria or mycosis cause malodorous products of decompensation in the perspiration

Treatment The use of the 10 per cent boracic acid powder on the foot and in the shoe daily is beneficial The foot may also be painted with an aniline dye (See Treatment of Dermatophytosis) In persistent cases in which the condition does not respond to ordinary treatment, roentgen rays may be utilized skin doses will result in a decrease of the glands In severe cases psychotherapy may be tried, sympathectomy produces complete and lasting dryness of the skin.

DERMATOPHYTOSIS

Etiology Dermatophytosis commonly called "athlete s foot" is the most common skin disease of the foot. This ringworm of the foot is caused by a group of closely related fungi known as dermatophytes From a therapeutic standpoint it is immaterial whether the organism responsible for the mischief is the Epidermophyton the Trichophyton or one of the yeast organisms such as *Monilia albicans* The fungi thrive in warm moist, alkaline media Heavy woolen hose and galoshes are factors in causing excessive warmth of the foot The perspiration of the foot is alkaline

Symptoms. The primary lesions are patches of whitish macerated skin between the toes particularly between the fourth and fifth toes When the fungi invade the skin of the toes or the plantar surface of the foot sharply demarcated areas of vesicles and crusts implanted on the reddened skin appear These vesicles vary in size and may be confluent to form bullae. They dry up spontaneously leaving a brownish crust Linear fissures occur between the toes in addition to the brown crusts of the former vesicles Areas of hyperkeratosis occur on the ball of the foot and heel.

Friction rub between the toes gives rise to a complication in the form of a hyperkeratotic lesion with maceration of the skin which is known as a "soft corn This friction rub is usually associated with a deformity of the fifth toe and protusion of the head of the proximal phalanx or a small exostosis in this area The patient frequently complains of itching of the feet The itching may come on suddenly for instance while riding in a streetcar or while driving an automobile. The symptoms may be of long standing and cause relatively little discomfort

The development of acute lesions or of complications usually brings the patient to a physician for consultation The acute or fulminating stage of mycotic disease of the foot is characterized by swelling blisters, and the oozing of a seropurulent material The itching is intense and the foot is painful This is a dangerous period, since pyogenic organisms may gain entrance through skin which has

lost its protective power Such a secondary infection may result in thrombophlebitis or lymphangitis.

In many protracted cases of fungus disease of the foot the nails are included. They are usually thickened brittle and yellowish with subungual hyperkeratosis All these changes appear most strikingly along the distal margin of the nail Such a nail provides sources of reinfection for the skin (Fig 162)

Treatment. *Prophylaxis* Dermatophytosis is highly infectious and is frequently contracted in swimming pools gymnasiums, and club shower rooms The foot must be dried thoroughly, particularly be



Fig. 162 Showing mycotic disease of the nails and skin of the foot. Note the *thickened, roughened, yellowish nail and the erythema of the skin*

tween the toes, and the patient should not go barefoot Ten per cent boracic acid powder may be used on the foot to keep the skin dry Many institutions are equipped with foot baths which contain a 1 per cent solution of hypochlorite which is changed every twenty four hours Both feet are immersed in this solution after leaving the pool or shower These baths have been successful in combating the spread of the disease Sanitary paper shoes are also used for this purpose.

Reduction of hyperhidrosis is an aid in preventing the development of dermatophytosis This is accomplished by soaking the feet in a solution of potassium permanganate (1 6000) several times a week. The hose are changed frequently in many cases twice a day

Light weight cotton hose are worn and the feet are exposed to the air as much as possible Exposure to sunshine and walking on dry sand are of value in the prevention of ringworm infection Venous stasis is relieved by *periodic elevation of the feet and the foot strain* is treated as described under Pes Valgoplanus

Treatment of Acute Phase In the acute phase of dermatophytosis where the vesicles are broken the skin may be denuded and a secondary infection may be present Treatment then consists in cleansing the foot gently with soap and water and applying a sterile gauze pack saturated with a solution of boric acid the pack is kept warm by means of a heat lamp The sterile pack includes the foot and leg The limb is elevated The patient must remain in bed and dressings are continued until the acute inflammation subsides and the swelling has disappeared

In milder cases of weeping dermatophytosis the foot is soaked daily in warm solutions of potassium permanganate (1 6000) for thirty-minute periods

Treatment of Chronic Phase In the subacute or chronic stages of the disease the nails and the skin between the toes are painted with a dilute solution of an aniline dye. The dye used is brilliant green which is a compound of one molecule of benzaldehyde and two molecules of diethylaniline This is diluted to make a 1 per cent solution with equal parts of benzene and absolute alcohol The painting is continued each night until there is no evidence of fissures and maceration Five per cent carbolfuchsin may be used in the same manner

During the latent period or when there is a hyperkeratosis salicylic acid which is not only fungicidal but keratolytic is of value It is used in a strength of 2 to 6 per cent In this connection one half strength Whitfield s ointment is useful *The salve should be rubbed* vigorously into the skin to produce a hyperemia which has a beneficial effect

The patient may be sensitive to one type of medication or a medication may lose its effect against the fungus so that it may be necessary *to vary the fungicidal agents* Gentian violet in 1 per cent aqueous solution may be painted on the affected areas daily

X Ray Treatment Roentgen therapy for this condition is advisable in cases that do not respond to topical remedies It has an inhibitory effect arresting the activity of the fungus and is useful in overcoming resistant infections however there is always danger of radiodermatitis from the accumulated effect of fractional doses Good results can also be obtained from ultraviolet irradiation The

skin may be desensitized with mercurochrome. The foot is exposed to the rays of the sun or an ultraviolet lamp

In generalized eruptions due to a primary infection of the foot with Trichophyton fungus intradermal injections of trichophytin extract may be tried Such therapy has not been beneficial, however when the infection was limited to the foot When the nails are infected fractional doses of roentgen rays may be used.

Removal of Infected Nails In most cases it is best to remove the nail The infected nail is free from its bed and may be removed without pain by means of a nail-cutting forceps The exposed area may then be treated with the aniline dye. Frequently there is an ingrown toenail as the result of the mycotic infection The operation for ingrown toenail may be carried out at the same time it is necessary to remove most of the nail This is followed by antimycotic medication

Other Measures In thrombophlebitis secondary to dermatophytosis, the limb must be kept at rest and the dermatophytosis treated. Roentgen therapy has been of some value in the acute stage of the thrombophlebitis but with subsidence of the dermatophytosis and elimination of the secondary infection the thrombophlebitis may be treated as described in the chapter on Circulatory Disturbance

Soft corns are so closely associated with ringworm infection that in these cases the antimycotic measures should always be used first The dilute brilliant green is usually the most effective therapeutic measure Ten per cent boracic acid powder is useful in keeping the interdigital spaces dry lamb s wool in these spaces allows for better ventilation and prevents friction rub which is a causative factor of the soft corn When the infection is cured and a soft corn is still present it may be necessary to remove the hyperkeratotic lesion and the underlying exostosis or protruding head of the proximal phalanx with a small, thin chisel In most cases however cure of the dermatophytosis and correction of the contracted toe will relieve the condition The toe may be treated by the corrective shoe or if necessary by the operation described for digiti quinti varus

Warts and calluses are frequently concomitants of dermatophytosis These lesions should not be removed surgically or by radium as long as the mycotic infection is present since it interferes with healing and there is danger of secondary infection with staphylococcus or streptococcus

CORNS

Corns are a common source of pain and disability in the foot The corn is an increase of epidermal cells which have become compressed

and consolidated to form a thickened, conical, horny layer The apex impinges upon the papillary body of the skin and causes pain along the nerves The central part of the corn may show necrotic changes due to decreased blood supply Between the corn and the bone an adventitious bursa frequently develops This bursa may become in flamed or a periostitis may occur The corn itself may become in fected or the bursa may become septic and the infection may extend to the joint of the toe.

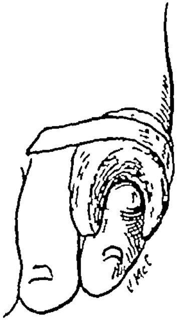


Fig 165 Felt pad applied behind corn to relieve pressure from shoe

Etiology A corn results from friction rub and pressure usually of the shoe against the skin on the dorsum of the toe Corns are gener ally associated with a deformity of the foot and contracture of the toes such as hammer toe The distal end of the proximal phalanx projects dorsally to cause pressure and friction rub against the shoe. In cases of contracted toe a corn may develop on the end of the toe and immediately beneath the nail due to friction rub If a postopera tive scar is subjected to pressure and rub from the shoe a corn may occur in the scar

Treatment The treatment consists in correction of the deformity relief from pressure and removal of the corn Correction of the de formity is the same as that for the treatment of contracted toes and hammer toe Where there is an acute inflammation around the corn

the foot is elevated and hot applications are used until the inflammation has abated. Pressure from the shoe can be relieved by applying a felt pad immediately behind the corn (Fig 163) This prevents friction rub against the corn and at the same time is a corrective force directed against the deformity A corn on the distal end of a toe and underneath the nail is treated first by removing the part of the nail that presses upon the corn correction of the flexion deformity prevents friction rub at this area When the contracture is firm it is best to apply a pad beneath the toe to hold the toe in an extended position This pad is of felt and is held in place with a narrow band of adhesive tape. It must be made certain that the tip of the elongated toe does not rub against the end of the shoe

A corn can be removed by the application of moleskin adhesive applied every night to the area the adhesive is left on the corn for twenty four to forty-eight hours and after each removal the softened tissue on the surface is scraped away The foot may be soaked for at least one-half hour in hot soapy water after which the corn is pared under aseptic conditions

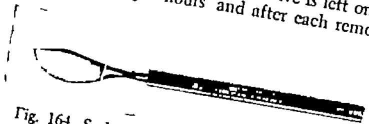


Fig. 164 Scalpel for removal of corns and calluses

Salicylic acid is the basis of most corn cures a useful preparation consists of 8 per cent salicylic acid in flexible collodion This preparation is applied directly to the corn and is replaced daily until the central plug separates or until irritation is produced

I have found it most satisfactory to cleanse the toe thoroughly with soap and water and then to apply alcohol to harden the skin

The thickened epidermis and the central nucleus are then removed carefully with a scalpel so that there is a funnel shaped central depression The pain is relieved by removal of the corn and cure is obtained recurrence is prevented by removal of the causative factors (Fig 164)

Roentgen treatment has given relief The skin around the corn is protected and dermal doses (150 r) are applied. Radium has been utilized in a similar way

Occasionally it is necessary to remove the corn by surgical means

The bursa underneath the corn is also removed if there is an exostosis this likewise must be excised with a thin narrow, sharp osteotome (Fig 165)

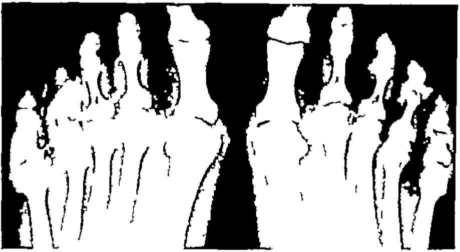


Fig 165 Partial phalangectomy for the treatment of corns involving the fourth and fifth toes

Soft Corns The soft corn is similar to the hard corn except that it occurs between the toes where there is a good deal of moisture. It usually occurs between the fourth and fifth toes and is the result of an

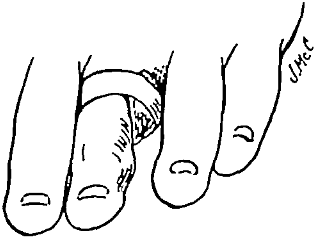


Fig. 166 Felt pad applied between toes to relieve pressure in soft corn.

enlargement and projection of the distal end of the phalanx at the interphalangeal articulation

The condition is very painful Pressure of the toes against each

other as in walking in a tight shoe will cause severe pain The soft corn appears as a circular whitish, macerated area with a depressed center It is frequently complicated by dermatophytosis An adventitious bursa is often present between the exostosis at the interphalangeal articulation and the corn

Treatment Treatment consists in thorough cleansing of the skin and eradication of the dermatophytosis Friction rub can be prevented by means of felt pads between the toes (Fig 166) Straightening of the toe prevents the projection of the distal end of the proximal phalanx. The corn gradually disappears and will not recur as long as the toe is held straight

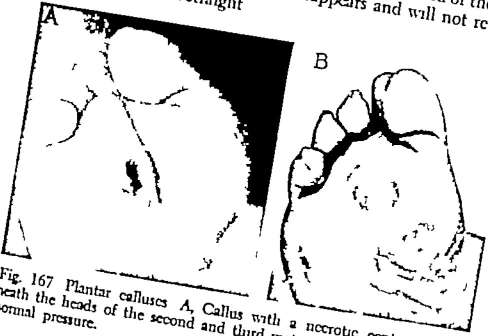


Fig. 167 Plantar calluses *A*, Callus with a necrotic center *B* callus beneath the heads of the second and third metatarsal bones as a result of abnormal pressure.

When it is not possible to correct the deformity it is best to remove under aseptic conditions the bursa and the projecting piece of bone with a sharp thin narrow osteotome. In some cases it is advisable, instead of removing the projecting piece of bone, actually to resect the distal end of the proximal phalanx. This is done easily with the use of a small pointed, strong jawed cutting forceps

PLANTAR CALLUSES

Calluses are circumscribed patches of hard thick skin caused by intermittent pressure There is hypertrophy of the corneous layer of the skin The callus is a protective mechanism against excessive pressure. It frequently occurs beneath the heads of the second third and

fourth metatarsal bones in connection with metatarsus latus (Fig 167) It may occur on the medial side of the great toe in case of a gait in which the foot is externally rotated (Fig 168)

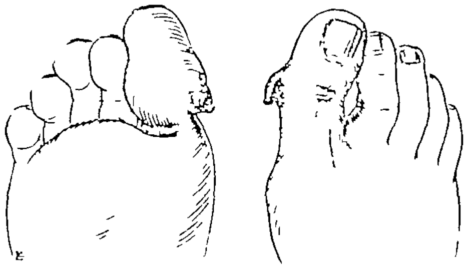


Fig. 168 Large horny callus.

Treatment. Removal of pressure will result in a spontaneous cure Pads immediately posterior to the heads of the middle metatarsal

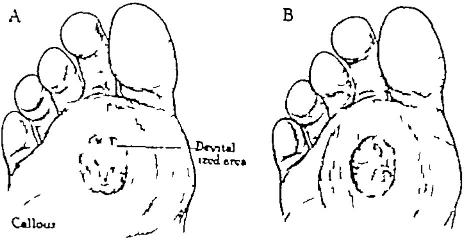


Fig 169 A. Sketch of a plantar callus B callus after it was pared with scalpel

bones and reestablishment of normal gait will gradually bring about the disappearance of the callus

When the callus is thickened hard and painful it may be pared with a sharp scalpel made for this purpose (Fig 169)

HYPERKERATOSIS

Hyperkeratosis is an overgrowth of the outer layer of the skin which occurs on the plantar surface of the foot. It is frequently a late stage of dermatophytosis (Fig. 170).

Treatment. Treatment of the hyperkeratosis in such an instance would consist in the use of heliotherapy or Whitfield's ointment. Or 5 per cent salicylic acid in lanolin may be rubbed vigorously into the skin. Walking barefoot on dry sand is helpful if this is practical.

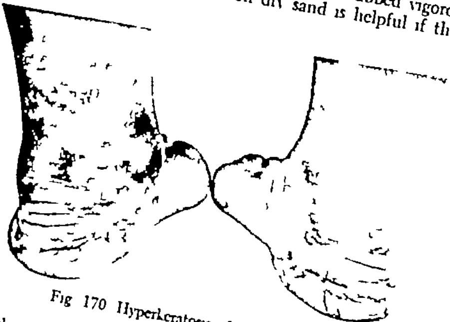


Fig. 170. Hyperkeratosis of the heels.

A hyperkeratotic condition of the skin also occurs in certain people without known cause. This type may be congenital. Inquiry should be made to ascertain if arsenic has been used as medication since it sometimes causes hyperkeratosis.

Roentgen treatment has been used in some cases with benefit, but most of the patients are best treated by thoroughly washing the foot with tincture of green soap, which softens the skin. This is followed by an application of 5 per cent salicylic acid in lanolin, which is rubbed vigorously into the skin several times a day.

VERRUCA PLANTARIS
(Plantar Wart)

Plantar warts are hypertrophied papillae of the stratum corneum of the skin covered by cornified epithelium. They are usually small and resemble a callus. The thick, dense epithelium penetrates deeply and forms a core similar to that of a corn. The papillae ex

tend upward beyond their normal level in the skin removal of the epithelial layers exposes them and causes bleeding. They may be single or multiple. Sometimes they are grouped or several hypertrophied papillae are sometimes covered by the same keratotic surface. Removal of the keratosis reveals multiple cores. Dark areas frequently seen in the callus are masses of coagulated blood which have escaped from a vascular papilloma (Fig 171)

These warts are caused by a filtrable virus. They are infectious and may be acquired in walking barefoot in swimming pools or

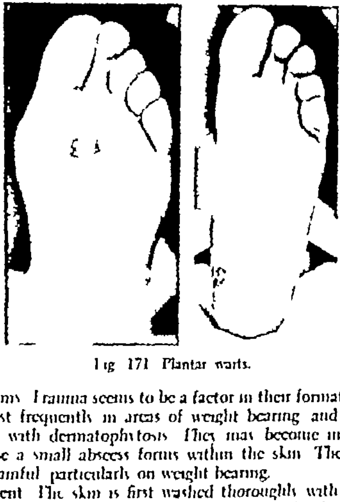


Fig 171 Plantar warts.

locker rooms. Trauma seems to be a factor in their formation. They occur most frequently in areas of weight bearing and are often associated with dermatophytosis. They may become infected, in which case a small abscess forms within the skin. They are frequently painful particularly on weight bearing.

Treatment. The skin is first washed thoroughly with soap and water. Dermatophytosis if present should be cured before the wart is treated. Radium in proper hands is the most satisfactory therapy. Roentgen rays are also of value. Before treatment with roentgen rays the hyperkeratotic thickening is removed with a scalpel. Surgical diathermy is effective but increases the danger of infection. The

wart is surrounded with injections of novocain and the electrode is applied to the hyperkeratotic area A minimum of weight bearing is allowed after treatment.

In all cases pressure over the area is relieved by means of felt pads or by a transverse bar on the outside of the shoe. Occasionally, in the case of a large single wart, it is removed by surgical enucleation

PERFORATING ULCERS

The plantar surface of the foot is subject to a peculiar chronic ulceration The ulcer is small circular, perforating and indolent but has a tendency to grow progressively worse Characteristic of the ulceration is a thickening of the skin surrounding a small sinus like area The ulcer is usually circular and about the size of a dime. The edges are horny and cracked In the center is a thin secretion which arises from the bone or the joint. For this reason the ulcer is sometimes considered a sinus The fact that it is painless is noteworthy

Etiology The etiology is not entirely known Usually the condition is spoken of as trophic ulcer The probability is that there is an interference with circulation and the circulatory disturbance may be on a neurologic basis However different types of lesions will bring about the same type of ulcer

In most cases several factors are involved. The mechanical pressure in standing and walking is a causative factor in that the tissues are subjected to trauma In other cases it is apparent that a vascular disturbance due to an alteration in the vessels themselves is at fault, for instance the ulcer is seen in cases of diabetes and endarteritis obliterans. Most cases are seen in connection with a lesion of the nervous system either a spinal lesion or a peripheral nerve injury Lesions of the central nervous system such as tabes dorsalis syringomyelia and spina bifida occulta are the most common underlying causative factors in cases of the perforating ulcer of the foot Occasionally a compression myelitis will be associated with a perforating ulcer of the foot Peripheral nerve injuries as the result of a direct blow a burn or a bullet wound have been observed in cases of perforating ulcer and are underlying causes Because of the loss of sensory impulses small injuries which normally would produce a defensive reactive hyperemia do not produce such a reaction because of the absence of such axone reflexes normal healing is impaired

A frequent cause of perforating ulcer of the foot is diabetes It is believed that in diabetes, pressure is also a factor and that the

inability to heal is rather due to the vascular disturbance than to the loss of healing ability caused by the disturbance in sugar metabolism

Excessive radiation therapy in the treatment of dermatological conditions such as plantar warts hyperhidrosis certain nevi and carcinomatous changes in the skin frequently results in ulceration Ulcers are invariably secondarily infected causing an even greater increase in scar tissue.

Symptoms. A small indolent perforating lesion appears on the anterior part of the plantar surface of the foot It occurs most frequently under the heads of the first or fifth metatarsal bones but may occur beneath the heads of the other three metatarsal bones when the transverse arch is insufficient The first symptom is usually swelling over these areas A callus then forms with loss of skin substance in the central area of the callus Gradually this forms a small ulcer from which a thin watery secretion exudes A probe in this ulcer usually leads to bone. The roentgenogram may show an exostosis of the bone beneath the ulcerated surface. This is usually of a roughened type and may be an additional factor in preventing the bone from healing

With the exception of the diabetic ulcer these lesions for the most part are painless The skin around the perforation is irregular avascular and horny There is danger of secondary infection of these points In cases of secondary infection there is a local inflammatory reaction and the condition may spread up the leg and form a lymphangitis or produce an abscess below the plantar aponeurosis With the infection there is also an increased tendency toward necrosis and local gangrene

Treatment *Prophylaxis* It is important to keep in mind the possibility of such a lesion occurring in conditions just described. To prevent undue pressure at any point in the foot there must be correction of deformity in some cases in others felt pads or properly built arch supports are used In addition anything that would tend to increase the vascular disturbance should be avoided such as exposure to extreme cold or retaining a dependent position of the foot for long periods without carrying out exercises The use of physical therapy to improve the circulation is a satisfactory prophylactic measure

Most important would probably be an attempt to bring the foot into normal position and carry out normal gait as a functional exercise In cases of syphilis antisyphilitic treatment is essential Potassium iodide is frequently used as a prophylactic measure In

cases of diabetes the use of insulin and control of the blood sugar by a diabetic regimen are important Local hygienic care of the foot is indicated The accumulation of cornified skin is prevented, and great care is used in these conditions in order not to injure the skin either in paring the ulcer or in trimming the nails

General Measures In the treatment of the ulcer it is necessary to eliminate the underlying cause whenever possible For instance in some cases this would mean antisyphilitic treatment or control of the diabetes In irremediable nerve lesions the pressure points are relieved by correction of the deformity if one exists When the ulcer is associated with a disturbance in the venous circulation elevation is of use. When there is interference with the arterial blood supply a slightly dependent position is preferable Heat and massage are also used to improve the circulation The cornified skin is carefully removed using aseptic precautions This treatment will frequently bring about a healing of the wound After the wound has healed, prophylactic measures are continued In some instances the stretching or division of the peripheral nerve has been advised. In peripheral nerve lesions massive doses of antineuritic vitamins (vitamins B_1 and B_2) are sometimes of value It has also been recommended that the ulcer be excised In some lesions as has been indicated, there is an exostosis of the bone which acts as an irritant and prevents healing. The exploration of the sinus or ulcer and removal of this exostosis are followed by healing In other cases particularly when there is a nerve lesion of the spinal column the destruction of the soft tissues is associated with actual destruction of the bone and there are marked osseous changes In some instances the lesions are so extreme that amputation is indicated

Ulcers following excessive irradiation may not heal under conservative treatment, owing to atrophy of the skin and arteriolar changes In these instances and where the ulcer is on the plantar surface of the foot it is necessary to excise the involved area and close the defect with a pedicle graft. This graft is best taken from the opposite calf Weight bearing is not permitted until sensation is present in the healed graft

PSEUDOMYCOSIS

(Indolent Ulcer)

The condition was first described by Castellani and is similar to that described by Meleney as burrowing ulcers Pseudomycosis of the foot has also been described by Hamilton

Pseudomycosis is an indolent ulcer occurring in the foot and leg

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PSEUDOMYCOSIS

(*Indolent Ulcer*)

The condition was first described by Castellani and is similar to that described by Meleney as "burrowing ulcers" Pseudomycosis of the foot has also been described by Hamilton

Pseudomycosis is an indolent ulcer occurring in the foot and leg

which is due to *Micrococcus mycetícus* (Castellani) It usually has an insidious onset swelling occurs and a small pustule may form This pustule instead of healing forms an ulcer Inflammation involves the deeper structures and a cellulitis is present There may be a single ulcer though usually the ulcers are multiple. They connect by means of sinuses underneath the skin so that the tissues are honeycombed The micro-organism may be recovered and grown on blood agar

Treatment. The treatment consists in rest cleansing the wounds and the application of dry heat After the ulcer is clean moist dressings of dilute potassium permanganate are applied Exploration of the sinuses and surgical drainage are used only when absolutely necessary since they spread the disease.

INGROWN TOENAIL

Ingrown toenail is the result of an aberrant growth of the nail, in which its margins press against the lateral soft tissue with resultant inflammation The paronychium often grows over the lateral margin of the nail.

Etiology Lateral pressure against the nail fold which in turn presses against the toe, is a causative factor Pressure against the medial side of the toe causes the nail to cut into the fold Pointed or high heeled shoes cause increased pressure along this medial margin of the toe In cases of pes valgoplanus with a flatfooted gait pressure is exerted on the medial margin of the toenail in walking with the foot everted, the body weight rolls over the inner side of the great toe instead of directly over the tip In cases of hallux valgus *the lateral margin of the nail of the great toe* is subjected to pressure by an overlapping second toe. Improper cutting of the nail is a common cause of ingrown toenail Cutting the nail too short or cutting out the lateral margin will tend to cause lateral growth of the nail into the soft tissue. If a small fragment is allowed to remain along the lateral margin in trimming the nail it will grow as a bayonet and penetrate into the soft tissue and cause pain Infection of the nail with fungi predisposes to aberrant growth and ingrown toenail

Symptoms The great toe is most frequently involved on the lateral or medial sides. Pain is increased with walking The margin *of the toe becomes red swollen* and tender to pressure. The nail fold becomes inflamed and hypertrophied and the surrounding tissue shows an inflammatory reaction The nail fold grows over

the margin of the nail and between it and the nail there is a thin whitish secretion (Fig 172) In chronic cases granulation tissue forms at times the pressure of the nail forms an ulcer on the undersurface of the nail fold

Treatment. *Prophylaxis* Prophylactic treatment consists in wearing broad shoes that have a straight medial margin and hose long

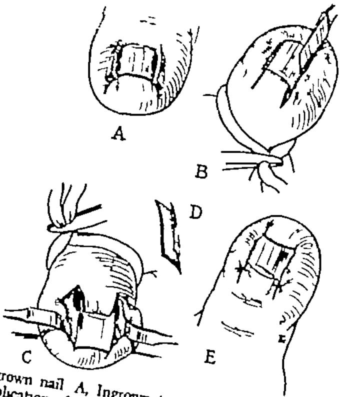


Fig 172 Ingrown nail *A*, Ingrown toenail, showing overgrowth of the nail fold *B* application of tourniquet and incision of eponychium Dotted line indicates the incision of the nail *C* exposure of the nail bed after removal of nail and cornified tissue shown in *D* the exposed matrix removed with a sharp periosteal elevator *E* Operation completed two sutures are used to close the eponychium

enough to assure freedom from pressure Reestablishment of normal gait is important The nails should be trimmed properly that is they should be cut straight across and not too short. Aseptic cleanliness consisting in scrubbing the nails with a nail brush and soap and water is of value

Treatment in Mild Cases In mild cases the margin of the nail is lifted with a tissue forceps and a small wad of cotton is pressed

underneath it. This cotton may be covered with collodion, which, when dry will hold it in place. This permits the nail to grow out without pressing into the soft tissue

If inflammation is present, treatment consists in elevation of the foot with applications of hot moist boric dressings When there *is a retention of secretion underneath the fold of the nail, the fold* can be drawn gently away from the nail and held by means of adhesive tape

Surgical Treatment In some cases the best treatment is surgical *removal of the involved margin of the nail under local anesthesia.*

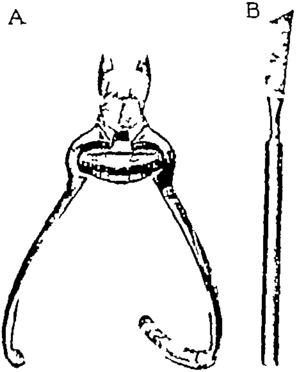


Fig. 173 A, Nail-cutting forceps, *B* nail-cutting scalpel

The anesthetic is injected at the base of the toe, blocking the digital nerves on both sides both dorsal and plantar nerves are anesthetized A small tourniquet is then fastened in the region of the injection

The operative technic I use is as follows the eponychium is incised and the divided portion is reflected from the root of the nail The part of the nail to be removed is then incised which is readily done with a nail-cutting forceps or with a special nail-cutting scalpel (Fig 173) That part of the nail which is to be removed is then rolled gently away from the bed and extracted from under

neath the nail fold Attached to the nail is cornified tissue growing along the undersurface of the nail fold, this is also removed The portion of matrix thus exposed is removed with a sharp periosteal elevator or with a thin chisel Care is taken to excise all this tissue; *if any is allowed to remain sharp spicules of nail will form which* will give rise to painful symptoms and necessitate a second operation for their removal The incision that was carried through the eponychium and *skin is closed with one or two sutures In cases of* chronic inflammation it is occasionally advisable to remove the paronychium

When the ingrown toenail is badly involved with fungi, the nail is removed under local anesthesia with the use of a tourniquet The nail is split in the middle, using a nail-cutting forceps or the special scalpel. Half of the nail is then grasped with a forceps and rolled away from the nail bed the other half is removed in a similar way



Fig 174 Removal of part of nail involved with mycosis after the operation for ingrown toenail

Next, the matrix that lies beneath the folds is exposed and destroyed Treatment is then directed against the mycosis (Fig. 174)

When recurrences have been encountered complete removal of the nail and the nail bed has been recommended *A transverse* incision is made through the eponychium and the nail is split and removed The nail bed and matrix are excised The inflamed paronychium *is dissected and removed Two lateral flaps of skin are* thus made and are easily drawn over the exposed phalanx and sutured to each other The region of the transverse incision is also closed with skin sutures

ONYCHAUXIS, ONYCHOGRYPOSIS

(Simple Hypertrophy of the Nail Hypertrophy with Deformity of the Nail)

Hypertrophy of the nail with or without deformity is usually observed in the nail of the great toe Onychauxis is a thickened

elongated nail the surface of which is irregular and opaque and the texture of which is like that of an animal's horn Beneath the nail, in the nail bed, is a brittle, grayish accumulation The nail may be shaped like a claw or a horn in which case the disturbance is called onychogryposis (Fig 175) The hypertrophied nail of this type is usually observed in trophic disturbances it is also sometimes seen in old people in association with improper cleanliness The condition



Fig 175 Onychogryposis

has also been ascribed to trauma There may be a familial tendency I have observed this condition in the great toe, and it was said to have occurred through three generations

Treatment The treatment consists in exact cleanliness and properly fitting shoes to prevent irritation of the nail Cleansing with a nail brush followed by the use of olive oil is of some value In young people the basal metabolic rate should be determined to rule out pituitary or thyroid insufficiency General hot baths and the use of hydrogen peroxide are recommended. It is sometimes necessary to remove the nail When the condition recurs it may be necessary to perform a radical operation

ONYCHATROPHIA

Onychatrophia is atrophy in which the nail is smaller and thinner than normal, and the distal margin is free. The nail may be attached to the toe by only a stump, the remainder having a tendency to grow upward. This atrophy of the nail may be the result of trauma or infection, in which cases it is limited to one or two nails. It may however be due to an endocrine disturbance, occasionally hyperthyroidism, in which case all the nails are involved. It may be a hereditary dystrophy, and lack of vitamins may be a causative factor. Psoriatic involvement of the nails may give a similar picture of atrophy with partial discoloration, usually yellowish or brown. There is elevation of the distal part of the nail and failure of the nail to grow.

Treatment. Treatment is directed against the underlying cause. Thyroid extract and vitamins are sometimes indicated.

ONYCHIA

Onychia is an inflammation of the nail bed which is usually the result of an injury plus infection. It may be due to foreign bodies under the nail, or to infection with bacteria or fungi. If the matrix is not involved, the nail will re-form; if the matrix is chronically inflamed, the nail plate will be discolored, distorted and cracked. The nail loses its normal color and becomes rough and loose. The nail bed is red and inflamed and at times there is pus beneath the nail plate. Onychia may be associated with a deformity of the nail.

Treatment. Surgical cleanliness after injury to the nail is important to prevent infection. In acute infections of the matrix the foot is elevated and sterile dressings soaked with warm boric acid solution are applied. When there is pus under the nail, the nail is removed in order to provide adequate drainage. The sulfa drugs or antibiotics are administered. The foot is kept at rest, and hot applications are used until the infection has subsided.

The nail may be involved with ringworm or onychomycosis. The causative fungi may be dermatophytes, moniliae or yeasts. The nail becomes thickened, rough, discolored and crumbly. It is usually a painless condition unless it is complicated by the nail growing into the folds. Onychia must be differentiated from psoriasis of the nails. Scrapings from the affected part of the nail may be examined under the microscope to determine whether fungus is present.

The treatment of onychomycosis has been discussed under Dermatophytosis

AINHUM

Ainhum is a constriction which occurs at the base of a toe, usually the fourth or fifth It is brought about by the formation of a deep groove in the digital plantar fold. It occurs in tropical countries and occasionally in the southern part of the United States The cause is not known The skin may ulcerate, in which case there is some pain If the constriction progresses, there is a vascular disturbance and the toe becomes gangrenous and finally drops off This takes about two years from the time of onset of the disease.



Fig. 176 Madura foot

Treatment. A longitudinal section across the groove on the plantar surface of the toe occasionally stops the progress of the disease. If this is not effective, the toe should be amputated

MADURA FOOT

Madura foot occurs in tropical countries and occasionally in the United States It is a chronic granulomatous disease caused by fungi It begins with a small painless swelling on the sole of the foot This swelling is soft deep-seated and tender The original lesion ruptures through the skin and discharges an oily seropurulent fluid which has a bad odor and contains black particles Multiple sinuses form There is little pain but the foot may become huge and the sinuses are a source of inconvenience (Fig 176)

Treatment Potassium iodide by mouth has been found useful in the treatment If a single toe is affected amputation of the toe may be adequate; when the disease is extensive it may be necessary to amputate the foot The amputation should be executed above the diseased area

CHIGO ITCH

Chigo disease is caused by a minute parasite, the chigo flea It occurs chiefly in Central America and the West Indies and only occasionally in temperate climates It attacks the skin of the foot and ankle particularly around the nails The female flea burrows into the tissues of the foot and deposits eggs, these develop larvae from which insects grow in ten days Sinuses are formed which may become involved secondarily with staphylococci

Treatment. The wearing of shoes usually prevents the disease Treatment consists in bathing with soap and water and forcefully extracting the flea

HOOKWORM DISEASE

In hookworm disease, uncinariasis cutis the skin of the foot is involved as a primary lesion The foot is the port of entrance for a generalized infection

REFERENCES

Castellani, Sir Aldo Further Observations on *Micrococcus mycetieus* and *Micrococcus metamycetieus* J Trop Med., 36.249 1933

Eller J J Plantar Warts, Callosities and Corns Am J Surg., 29-444 1935

Heifetz, C. J Ingrown Toe-Nail Am J Surg., 38 298, 1937

Jones, J W., and Alden H S Maduromycotic Mycetoma (Madura Foot) J.A.M.A., 96.256, 1931

Marcus, I H., and Weinstein J *Dermatomyositis, Report of a Case with* a Review of the Literature. Ann Int. Med., 9-406, 1935

Melody J A. A Simple Treatment for Epidermophytosis of Feet. Mil. Surgeon, 83 250 1938

Meleny F L., and Johnson, B A. Further Laboratory and Clinical Experiences in the Treatment of Chronic, Undermining, Burrowing Ulcers with Zinc Peroxide. Surgery 1 169 1937

Pardo-Castello, V Diseases of the Nails Springfield Ill., Charles C Thomas, 1936.

Strauss, M J Onycholysis and Onychomadesis Arch Dermat & Syph., 14 503 1926.

26

SPECIAL CARE OF THE FEET

CARE DURING PREGNANCY

Normal pregnancy predisposes to disorders of the feet because there is an increase in the weight load on them and the functional capacity of the foot is decreased to some extent because of limitation of normal activity. For these reasons the orthopedist is in complete agreement with the obstetrician who guards his patients against abnormal increases in weight during pregnancy and recommends that the pregnant woman carry out normal activity as long as possible. Since there is a tendency toward foot strain and ultimately to pes valgoplanus, prophylactic measures are indicated. As long as the increase in weight is within normal range and there are no complications, walking is a beneficial exercise. As a result of wearing high heeled, stiff-shanked shoes, many women have interfered with normal gait and have a tendency toward pes valgoplanus before the pregnancy. The extra strain of pregnancy then exaggerates the condition and causes symptoms.

Stiff-shanked shoes with soft felt pads inside are helpful in preventing foot strain and the development of pes valgoplanus. A street shoe with a Cuban heel and a broad weight bearing surface and fairly thick sole, as described in the section on Shoes, may be used. In addition to protecting the foot it is necessary to exercise it. For this purpose corrective shoes are prescribed. Normal walking is the best exercise for the foot. The patient can accommodate herself to the low heeled corrective shoe in the early stages of pregnancy. Since most patients have worn high heeled shoes and have acquired a short tendo achillis, however, the low heeled shoe, when first worn, will cause a strain in the calf of the leg and in the back. For this reason the low heeled shoe is worn at first only for short periods of five to thirty minutes at a time several times a day; the time is then gradually increased each day until the shoe can be worn with comfort.

After the patient has become accustomed to the low heeled shoe and the tendo achillis has been stretched, which takes from seven to ten days, corrections may be applied to the outside of the shoe The inner side of the heel is raised 1/32 inch, giving a slightly inclined plane and holding the heel in varus the comma-shaped transverse bar is applied posterior to the heads of the four medial metatarsal bones The bar is 1/4 inch higher on the outer than on the inner side, giving an inclined plane in the medial direction Since the corrective shoe has a pliable leather sole rather than a stiff metal shank, the normal rolling gait is easily executed with the corrections applied.

In order to carry out a normal rolling heel and toe gait it is necessary to hold the body in the erect position The improved carriage affects the body mechanics in such a way that it lessens the strain in the lumbosacral area, while the normal demand in holding the body upright increases the strength of the abdominal and back muscles This in turn helps prevent functional decompensation and low back pain following pregnancy

Since labor and the rest in bed following delivery result in muscular weakness it is necessary to reestablish normal strength after pregnancy in order to prevent strain of the foot and back. Thus means that the patient should have periodic rest, at least fifteen minutes every four hours or even every two hours depending upon the amount of weakness present When weight bearing is begun the padded stiff-shanked shoe or corrective shoe should be worn to protect against strain

CARE AFTER PROLONGED ILLNESSES

After prolonged rest in bed because of chronic illnesses such as tuberculosis or fracture of the hip foot strain may be expected when walking is resumed The same prophylactic measures are indicated in these cases

CARE IN CASES OF RICKETS

In rickets the foot is subjected to strain as a result of structural weakness The softened bones and the impaired muscle tone cause an overstrain and, as is typical of the strained foot there is a tendency toward pes valgoplanus Furthermore in the presence of a rachitic genu valgum there is an increased inclination for the heel to continue in the valgus position with the resultant pronated foot In rachitic bowleg there is also a predisposition toward pes valgo-

planus the valgus of the heel compensates for the increased bowing of the leg

The treatment of rachitic pes valgoplanus is essentially the treatment of rickets In a weak foot with pes valgoplanus and genu valgum the corrective shoe has a beneficial influence, not only in developing a normal foot but also as a corrective force against the genu valgum The more normally the lower extremities are used, the more nearly normal will be the contour assumed by the structures. In other words the reestablishment of normal physiologic use will tend toward the reestablishment of normal anatomic structures

In cases of compensatory pes valgoplanus with bowleg, it is necessary to correct the bowleg In most instances this is a problem of a general rachitic regimen In the exceptional case surgical correction of the bowleg is necessary The principal treatment, therefore, is a thorough antirachitic regimen with mechanical correction of the deformities present

27

TECHNIC OF LOCAL ANESTHESIA

Fractures of the Ankle. Local anesthesia can be used satisfactorily for setting fractures and dislocations in the region of the ankle The method is relatively simple in recent fractures since the osseous structures are near the surface and a hemorrhage is formed that surrounds the injured tissue Injection of an anesthetic into this hemorrhage will carry it to all the injured structures

The skin is cleansed thoroughly and the area is surrounded with sterile towels and drapes as for an open operation

A fine hypodermic needle (1 inch 25 gauge) on a 20 cc. syringe is then used to inject 2 per cent novocain into the skin to form an intradermal wheal The needle is then replaced on the syringe by a heavier and longer one (1¼ inch, 23 gauge) which penetrates the skin through the wheal While injecting the fluid the needle is forced through the tissue until it is felt to enter the hematoma or joint cavity The plunger of the syringe is then withdrawn drawing as much blood or serosanguineous fluid as possible into the syringe The needle is allowed to remain in situ The fluid in the syringe is then replaced with 20 cc. of 2 per cent novocain The syringe is again attached to the needle and the anesthetic is slowly injected The needle is then withdrawn and a sterile dressing placed over the point of entrance. If desired the opening may be sealed with a sterile dressing and collodion

Anesthesia sets in soon afterward The injured tissue is bathed in the anesthetizing fluid. To disseminate the fluid throughout the limb the ankle may be massaged gently with a light upward stroke which will force the fluids higher into the subcutaneous area and decrease the swelling After a few minutes satisfactory anesthesia for reduction will be obtained The anesthesia will last for several hours permitting setting of the fracture and checking of the posi

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tion by roentgenogram If the reduction is not satisfactory a second attempt may still be carried out under the original anesthesia

Local anesthesia is contraindicated in cases of infection and in cases of compound fracture or abrasion of the skin wherein infection is imminent. When the hematoma has become organized complete anesthesia will not be obtained by injecting the novocain into the site of fracture the surrounding tissue may then be further injected with the anesthetic Sometimes both malleoli are fractured and separate hematomas result in which event it is necessary to inject the anesthetic on both the lateral and medial sides

Local Anesthesia of Entire Foot Complete block anesthesia of the foot can be effected by injecting a 1 per cent solution of novocain with 3 minims of adrenalin (epinephrine) per ounce of solution into both the anterior and posterior tibial nerves

The patient lies on his back with the knee flexed and the sole of the foot resting on the table near the edge A line is drawn around the ankle at the base of the medial malleolus, and a wheal is raised on this line at the lateral margin of the tendon of the tibialis anterior muscle Paresthesia can be elicited along the course of the nerve by pressure over this area A 1½ -inch 24 gauge needle is connected to a 10 cc syringe, introduced through the wheal and advanced until it reaches the tibia It is then withdrawn about ¼ inch, and injection is made of 5 cc of 1 per cent novocain With the foot in the same position a wheal is then raised on the inner side of the tendo achillis on the line already traced around the ankle The needle is passed forward through the wheal until the posterior surface of the tibia is reached The needle passes through fascia and fat and pierces the deeper fascia and 5 cc of 1 per cent solution of novocain are injected just outside the tibia beneath the fascia

The plunger is withdrawn before injection and if blood is obtained the position of the needle is altered

A ring of subcutaneous infiltration encircles the ankle connecting the anterior and posterior wheals The anesthetic is injected as the needle is introduced into the tissue so that the solution precedes the point of the needle As much of the solution as is required is released from the syringe while the needle is withdrawn About five minutes time is allowed for the anesthetic to take full effect

Removal of a Plantar Wart or Callus The needle should penetrate the skin on the plantar surface just at the margin of the wart The anesthetizing solution 2 per cent novocain with adrenalin (3 minims of adrenalin per ounce of solution) is injected underneath the wart Enough solution is injected so that it extends beyond the

margins of the wart. This permits removal of the wart through an elliptical incision within the field of anesthesia

Ingrown Toenail Operation. Two cutaneous wheals are made on the dorsal surface of the great toe at its base, one on the medial and the other on the lateral side. The toe may then be encircled with a subcutaneous injection of 0 5 or 1 per cent novocain solution The needle is introduced through the cutaneous wheal until the base of the first phalanx is encountered It is then withdrawn about $\frac{1}{16}$ inch and 2 cc of 0 5 or 1 per cent novocain are injected in the region of the digital nerve This is done both on the medial and lateral sides of the toe The anesthesia obtained in this way will permit the application of a tourniquet, which consists of a small rubber tube clamped with a forceps

Hammer Toe Operation Sufficient anesthesia may be obtained by encircling the base of the toe with a subcutaneous injection of 1 per cent novocain. The digital nerve may be injected with 2 cc. of solution on each side of the toe The needle always enters from the dorsal side. In cases of vascular disturbance adrenalin is not added to the anesthetic when the toe is encircled, since it increases interference with the blood supply Small rubber tubing can be fastened at the base of the toe to act as a tourniquet.

Amputation of a Toe. A dorsal wheal is made on each side of the base of the toe Both digital nerves are then injected with the anesthetizing solution and the infiltration is carried posteriorly between the metatarsal bones until complete anesthesia is obtained. The solution is injected from the dorsal surface to the plantar surface

Indications for General Anesthesia For major operations and manipulative procedures general or spinal anesthesia is preferred When available, ethylene administered by an expert anesthetist receives preference Sufficient depth of anesthesia can be obtained by ethylene or nitrous oxide to give complete relaxation for manipulative procedures In major operations a bloodless field is most easily and effectively obtained with the use of a blood pressure apparatus as a tourniquet applied just below the knee First a single layer of 3-inch roller gauze bandage is wrapped smoothly to fit the contour of the leg from the knee, extending distally for about 8 inches being careful that no constriction of the venous circulation occurs This is to prevent the formation of skin blisters by the blood pressure cuff which cannot be applied as smoothly The blood pressure cuff is then applied without tension over this layer of gauze A 3-inch roller gauze bandage is applied over the blood pressure cuff to hold it in place After preparation of the foot for surgery the extremity is elevated

for two minutes and the blood pressure cuff inflated to 280 mm of mercury before the extremity is lowered and draped. At any time during the procedure the pressure in the cuff may be released to check bleeding and then reinflated for continuation of the operative procedure.

Spinal anesthesia in experienced hands can be used instead of general anesthesia.

REFERENCES

Cullen, S. C.: Anesthesia in General Practice. Chicago, Year Book Publishers, 1946.

Dillon, J. B.: Choice of Anesthesia in Orthopedic Surgery. *J.A.M.A., 133*:829, 1947.

Dye, I. C.: Advances in Anesthesia. Bull. of U. of Maryland Sch. of Med., 32:23, 1947.

Fundamentals of Anesthesia, an Outline. Prepared by the Sub-Committee on Anesthesia, Division of Medical Sciences, Nat. Research Council, 2d ed. Chicago: American Medical Association, 1944.

28

SPECIAL TECHNICS IN THE CARE OF THE FEET

Compression Bandage. The technic of applying a compression bandage is simple and can be taught to the patient or a relative of the patient. A roll of sheet wadding (6 inches wide for an adult and 3 inches wide for a child) is wrapped around the foot and leg, starting just behind the toes; three to six layers are wrapped around the ankle area, while two layers are sufficient at the toes and below the knee. A gauze bandage (3 inches wide for an adult and 2 inches wide for a child) is then wrapped snugly over the sheet wadding. This is fastened with adhesive strips wrapped spirally over the foot and leg. When the bandage is replaced by someone other than the physician, a 3-inch Tetra or Ace bandage may be used instead of gauze.

Gibney Type of Bandage. The patient is seated on the examining table with his foot resting on a stool. The foot is brought to a right angle with the heel in slight varus by a strap which passes around the forefoot and is held taut by the patient. A 10-yard roll of ½-inch waterproof adhesive with a firm back, is started on the posterior part of the outer side of the leg, about 6 inches above the lateral malleolus and brought around underneath the heel to the corresponding level on the medial side. The posterior surface of the heel is covered with a double layer of sheet wadding. A cross strip of the adhesive is started at the base of the fifth toe and run over the first strip, then over the sheet wadding at the back of the heel, to end near the head of the first metatarsal bone. A second longitudinal strip follows the course of the first, running from the outer side of the leg under the heel to the medial side; this strip overlaps the margin of the first. A second transverse strip follows the course of the first one, overlapping its margin and starting and ending a little shorter than the first.

This interlocking of the strips is continued until a solid support has been formed. The ankle is protected and there is no adhesive tape over the area of the dorsal artery of the foot to interfere with circulation. The ends are cut so that they are level and form a neat bandage. The bandage is finished by sealing the upper ends of the longitudinal strips with a cross piece and additional cross strips are then wrapped over the longitudinal strips at 2 inch intervals to hold them firmly to the leg (Fig. 177).

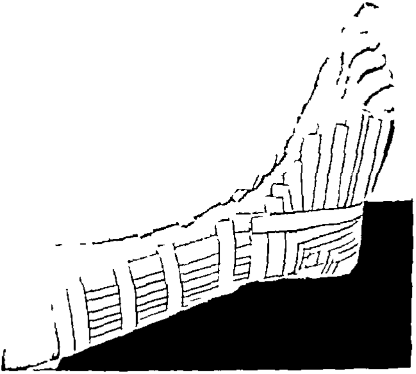


Fig. 177. Gibney bandage.

This bandage may be worn for seven to ten days. On the fourth or fifth day it may be reinforced since the adhesive tends to slip on the skin. The bandage is removed with benzine or some other nonirritating cleansing fluid on cotton and it may be replaced as long as the skin is not irritated.

To prevent irritation of the skin and to simplify removal of the adhesive, the skin is painted with *compound tincture of benzoin* before the adhesive is applied.

Strapping for Foot Strain and Pes Valgoplanus. The patient sits on the examining table with his foot resting on a stool. The heel is brought into varus and the position maintained by a gauze strap

the ends of which are held tightly by the patient. A strip of firm backed, waterproof adhesive 1 inch wide is started at the outer side of the heel below the level of the lateral malleolus The adhesive is drawn underneath the heel forcing it into a varus position It is then passed medially over the bottom of the heel to the anterior part of the leg, where it is ended 6 inches above the medial malleolus A second strip overlaps half of the first and follows the same course, These bands are repeated until the outer side of the heel is covered with adhesive. The longitudinal strips are then covered with a layer of cross strips below the lateral malleolus Cross strips at 2 inch intervals are used to hold the longitudinal strips on the leg This com

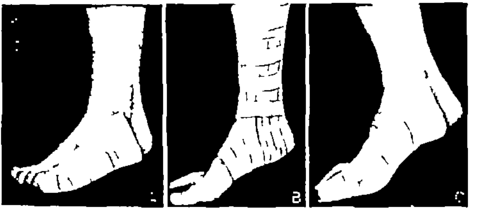


Fig. 178 A, Strapping for simple fracture of the small toe B Simple strapping used for foot strain C Strapping used for simple fracture of the large toe.

pletes the corrective strapping for the valgus deformity the gauze strap is removed (Fig 178)

With the patient in the same position the head of the first metatarsal bone is forced in a plantar direction the thumb presses on the dorsum of the great toe and the fingers press upward underneath the heads of the metatarsal bones of the three middle toes A strip of adhesive tape 1 inch wide is started medial to the base of the great toe on the dorsum A double layer of sheet wadding is placed over the inner margin of the head of the first metatarsal bone The adhesive is drawn medially and downward over the sheet wadding pad and passed beneath the anterior part of the foot The outer surface of the foot is padded with sheet wadding proximal to the head of the fifth metatarsal bone With pressure from above, the fifth metatarsal bone is forced in a plantar direction and held in this position while the original adhesive strip is drawn over the pad and across the dorsum of the foot The dorsum is also padded with a double layer of

sheet wadding to protect the dorsal artery. The adhesive is continued laterally and upward to end above the medial malleolus. A second strip of adhesive follows the course of the first and overlaps its margin (Fig 179)

PLASTER OF PARIS CASTS

Plaster of paris bandage may be prepared in the operating room or a good commercial product such as the "Specialist" may be used.

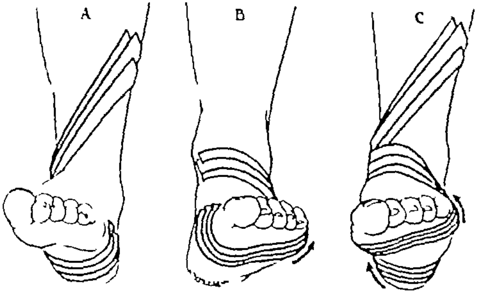


Fig 179 Sketches of foot strapped for foot strain and pes valgoplanus A, Strapping to bring the heel into varus *B* strapping to bring the anterior part of the foot into pronation *C*, combination of strappings shown in *A* and *B* to bring the heel into varus and the anterior part of the foot into pronation

The 6-inch width with a setting time of five to seven minutes is desirable for the foot and leg.

The roll of bandage is immersed in sufficient water to allow ample penetration. Care must be exercised to prevent the plaster from seeping out of the bandage. As soon as bubbles cease to appear the bandage is removed by grasping it at each end; it is compressed slightly to expel excess moisture and stroked gently to smooth it. Then it is allowed to lie exposed to the air until it reaches the consistency best suited to the surgeon's task.

The skin is washed thoroughly with soap and water. The bandage is applied by unrolling it on to the limb; each turn overlaps the previous layer by half its width. It is constantly smoothed and molded with the hands to insure cohesion between the layers and proper

shaping The bandage may be tripped to take up the slack, but should not be reversed If the bandage should become tight it may be cut with a scissors

Reinforcements are valuable to provide extra strength They are made by using layers of plaster bandage 12 inches long and 3 inches wide. As many as twelve layers may be necessary After immersion and application circular winding of the bandage secures them in place.

All of the bandage should be applied and molding completed before the plaster becomes hard

Unpadded Cast for Complete Fixation of the Ankle Joint. The cast must extend from well above the knee to beneath the toes Thus prevents the gastrocnemius muscle, which has its origin on the femur and insertion into the calcaneus from acting at the ankle joint whenever the knee is flexed or extended

The limb is held by an assistant in the position which has been accurately established by the surgeon The bandage is started at the ankle and continued down over the foot including the toes it is then started up the leg to the upper thigh Longitudinal reinforcements are placed beneath the ankle and the knee and covered with as many layers of circular bandage as are necessary for a firm cast

The back of the heel is guarded carefully against pressure The palm of the hand not the fingers is used to support the limb under the calf and thigh never under the heel or tendo achillis

When the limb is enclosed, the position is checked and the plaster molded until it becomes firm Then if the cast is not strong it is reinforced by the further application of plaster The position desired must be retained as accurately as possible during application so that the minimum amount of alteration is necessary in the final check of position

The cast is trimmed so that the tips of the toes are seen or when desired to the base of the toes The edges of the cast are made smooth and turned out with pressure from the thumb and fingers The cast is placed on soft pillows and exposed to an infra red lamp an electric fan may also be used to promote drying

Plaster Cast for Ambulatory Treatment. The cast is applied directly to the skin or the foot and leg may first be covered with stockinet or sheet wadding

As a rule, the foot is held in the midposition This means slight varus at the heel the anterior part of the foot brought into relative supination and the foot at a right angle to the leg After fusion of the ankle joint slight plantarflexion is required to allow for the heel

of the shoe; it should be greater for women than for men A plaster of paris bandage 6 inches wide encircles the leg above the ankle The bandage is continued around the leg up over the knee

The bandage is applied so that its greatest strength is at the ankle, which is the point of maximum strain Four to six strips of plaster reinforcements are used from the plantar surface of the cast over the back of the ankle up to the calf

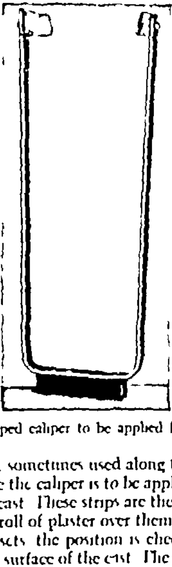


Fig 150 U shaped caliper to be applied for walking cast

Reinforcements are sometimes used along the medial and lat[illegible] sides of the cast where the caliper is to be applied to prevent it fr[illegible] pressing through the cast These strips are then included in th[illegible] by wrapping another roll of plaster over them

Before the plaster sets the position is checked A footbo[illegible] applied to the plantar surface of the cast The assistant holds th[illegible] above the knee it is his task to apply constant even pressure to [illegible] foot from above The operator holds the footboard against

The f[illegible] is a board about 6 by 12 inches covered with a piece [illegible] rubber or [illegible] position to make removal of plaster simple

chest In this way he can control the position of the foot accurately he is in position to increase or decrease the dorsiflexion and plantar flexion and his hands are free to continue the molding of the plaster The areas below the malleoli and on both sides of the tendo achillis are molded. The footboard is then removed and the plantar surface of the cast is molded to bring out the contour of the longitudinal and transverse arches The plaster is molded out over the tips of the toes

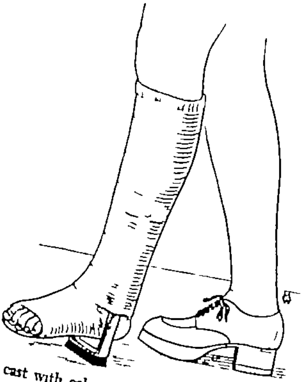


Fig. 181 Plaster cast with caliper attached Note raise of shoe on opposite foot to simplify walking

As soon as the cast is firm it is trimmed The dorsa of the toes are exposed to their bases unless fixation of the toes is required for instance if they were contracted in which case the cast is trimmed flush with their tips The tips of all the toes must always be visible to check the color If there is pressure on the fifth toe the cast is split longitudinally and the plaster turned back until the pressure is relieved.

After the cast has hardened the walking caliper is applied This is a U-shaped piece of steel with rubber attached to its cross piece (Fig. 180) The arms of the caliper have small malleable cross pieces which are molded to the cast The caliper is applied so that the arms

of the shoe; it should be greater for women than for men A plaster of paris bandage 6 inches wide encircles the leg above the ankle. The bandage is continued around the leg up over the knee.

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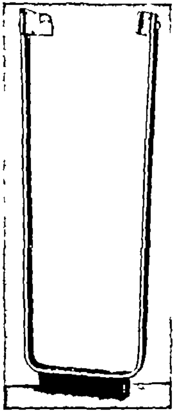


Fig 180 U-shaped caliper to be applied for walking cast

Reinforcements are sometimes used along the medial and lateral sides of the cast where the caliper is to be applied to prevent it from pressing through the cast. These strips are then included in the cast by wrapping another roll of plaster over them

Before the plaster sets the position is checked. A footboard* is applied to the plantar surface of the cast. The assistant holds the leg above the knee it is his task to apply constant even pressure to the foot from above The operator holds the footboard against his

* The footboard is a board about 6 by 12 inches, covered with a piece of rubber or composition to make removal of plaster simple

chest. In this way he can control the position of the foot accurately he is in position to increase or decrease the dorsiflexion and plantar flexion, and his hands are free to continue the molding of the plaster The areas below the malleoli and on both sides of the tendo achillis are molded The footboard is then removed and the plantar surface of the cast is molded to bring out the contour of the longitudinal and transverse arches The plaster is molded out over the tips of the toes

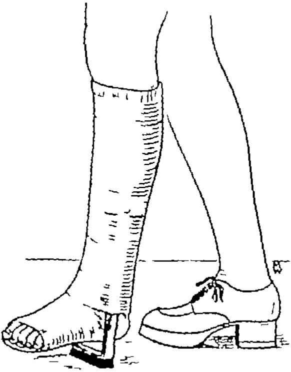


Fig. 181 Plaster cast with caliper attached Note raise of shoe on opposite foot to simplify walking.

As soon as the cast is firm it is trimmed The dorsa of the toes are exposed to their bases unless fixation of the toes is required, for instance if they were contracted in which case the cast is trimmed flush with their tips The tips of all the toes must always be visible to check the color If there is pressure on the fifth toe, the cast is split longitudinally and the plaster turned back until the pressure is relieved.

After the cast has hardened the walking caliper is applied This is a U-shaped piece of steel with rubber attached to its cross piece (Fig. 180) The arms of the caliper have small malleable cross pieces which are molded to the cast The caliper is applied so that the arms

run parallel to the midline of the leg This brings the weight bearing axis posteriorly on the foot and in the region of the heel The arms extend about 2 or 3 inches below the plantar surface of the cast. The extension must be high enough to permit an easy roll off the bottom of the foot The greater the plantarflexion, the higher the bottom of the cast must be from the cross piece of the caliper The upper end of the caliper is fastened to the cast by encircling it with a plaster

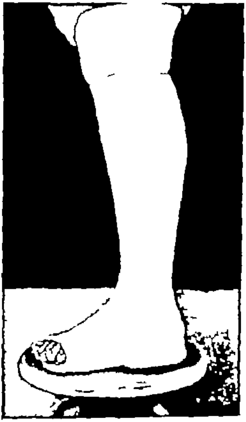


Fig 182 Walking cast with heel attached.

bandage 3 or 4 inches wide The bandage is wrapped down to the ankle region Here the plaster is passed underneath the caliper to encircle the arms forming a figure 8 This is repeated until the iron is firmly fixed The plaster is allowed to become hard before weight bearing is permitted (Fig 181)

If a heel is desired instead of the caliper a walking cast is made as described above up to the point where the caliper is used The cast is permitted to harden for twelve to twenty four hours A heel is then made of firm felt ¼ inch in thickness three, four or even five layers are necessary This can be applied to the cast in layers with

adhesive strapping. The patient walks in order to try the effect. With a little experimenting the optimum height is established and the heel is firmly attached with adhesive

In some cases a heel is made of plaster Plaster bandages may be folded upon each other to make the heel with the footboard placed on the plantar surface of the cast the plaster heel can be molded to the proper height. Rubber heels which are kept in the plaster room or a section of casing of an automobile tire can be used These heels are fastened to the cast with a plaster of paris bandage (Fig 182)

Plaster Cast for Extension to the Toes Snug fitting stockinet is used to cover the foot and leg. A double layer of sheet wadding is applied to the posterior surface of the heel a single layer is placed anterior to the ankle joint A plaster of paris cast is then formed from the toes to just below the knee The cast is trimmed to expose the dorsa of the toes The stockinet is reflected back over the margins of the cast and fastened onto it with two turns of plaster bandage as soon as the cast is firm A heavy steel wire or strip of metal about 20 inches long is bent into the desired shape and the ends are fastened to the sides of the cast just below the ankle extending in front of the toes

Under aseptic conditions a sterile wire loop fashioned in a manner similar to a safety pin is passed through the fleshy part of the toe The wire can be made to perforate the bone if desired The ends are then interlocked Traction may be applied to this wire loop without compressing the soft tissues An elastic band is run from the metal loop attached to the cast to the small wire loop attached to the toe. The amount of traction desired is controlled by the strength and tension of the elastic band There is continuous traction as long as the bands do not slip these bands are adjusted as often as necessary to assure adequate traction The rubber bands can be fastened to indentations or grooves made on the metal loop fastened to the cast.

Plaster Cast in Static Paralysis of the Foot. Whenever there is reflex spasm stimulation of the skin will give rise to an increase of muscle spasm and a greater tendency toward deformity For this reason a cast used in spastic conditions should be well padded

The foot is brought into the midposition the heel is brought over to the midline, the adduction and supination of the anterior part of the foot are corrected and the foot is brought to a right angle Correction is gained by slow firm steady pull. Sudden and forceful movements are avoided The skin is first covered with stockinet and the foot and leg are encased in sheet wadding of 5-inch width until

a three-to-five layer thickness has been obtained. A plaster bandage 3 to 5 inches wide, depending on the size of the limb is then started above the ankle and wrapped over the foot and leg. About three layers of bandage are sufficient

Unna Paste Boot. An Unna paste boot is applied when swelling is at its minimum The swelling usually recedes during the night. If the boot is to be applied late in the day the limb should be kept elevated to prevent recurrence of the swelling If the limb has been in cast, the Unna paste boot is applied immediately after the cast is removed

I use a modification of the original Unna paste, made in the following manner the ingredients are 100 parts of zinc oxide, 300 parts of glycerin, 400 parts of water and 200 parts of gelatin Heat the glycerin and add the gelatin slowly stirring all the time. Next, add the water slowly keep stirring and keep heating Pour this hot mixture slowly over the zinc oxide and continue to stir until cool and the mixture begins to harden When cooled, it results in a solid white mass which is cut into strips for later use. To prepare it for application, it is heated in a double boiler Only as much of the material as is required for the treatment is prepared it is best to discard whatever prepared material is not used.

The patient is permitted to recline on a low solid table with pillows under his back and head The limb is elevated the knee flexed, and the leg held so that it is parallel to the table The skin is cleansed but not shaved Benzine may be used to remove grease and the leg and foot are washed with soap and water The skin is dried thoroughly before the boot is applied. The foot is at a right angle to the leg, and the heel and anterior part of the foot are in the position of choice The paste is then painted on the sole of the foot. To avoid having the paste too hot, the coated brush is held in the air for a minute or less before bringing it in contact with the skin The foot and leg are completely covered with the paste.

A gauze bandage, 3 inches wide, is passed from the middle of the outer side of the leg around the heel to the same height on the inner side, forming a stirrup A short strip of gauze bandage is passed from in front of the ankle around over the heel. Each strip is covered with Unna paste before a new bandage is applied

A gauze bandage, 2 or 3 inches wide, depending on the girth of the leg is then wrapped in a spiral manner from the toes to below the knee This bandage must be snug, but the margins should not cut into the tissues nor should the bandage overlap The margin of each spiral turn comes in accurate contact with the spiral turn below it It may be necessary to trip the lower margin of the bandage

with the finger to take up the slack. The small V-shaped overlap thus formed is removed with scissors The gauze is quickly painted with an even coat of Unna paste

The entire process is then repeated to form a second thickness The first coat acts partially as a nonconductor and protects against excessive heat.

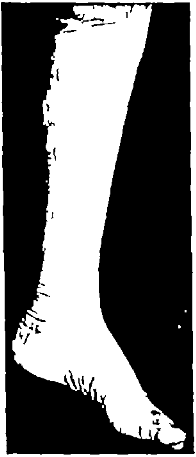


Fig 183 Unna paste boot Note that the foot is included

In applying the second coat the bandage is applied so that the middle of it falls over the margins of the first spiral twists The paste is painted on quickly- a second assistant or nurse may apply it to one side of the limb while the surgeon covers the other The edges of the boot are trimmed with bandage scissors The upper edge of the boot is loosened from the skin for about ¼ inch after it has been trimmed. This margin is watched to prevent friction rub

The tension with which the bandage is wrapped is most important It must be snug enough to hold the soft tissues without cutting in at the edges The boot offers a smooth surface when it dries (Fig

183) The surface is painted with a preparation of 6 per cent forma lin in alcohol to make it dry and hard so that it will not stick to the stocking

With the foot encased in a snugly fitting Unna paste boot the *effect of muscular action as in walking is to pump the blood* out of the decompensated venous system The demand of the exercised muscles for arterial blood reestablishes a normal flow The boot is beneficial in all cases in which there is a venous impairment provided the arterial supply has not been too greatly impaired The full effect of the boot is reached with physiologic exercises

PHYSICAL THERAPY

Heat Heat is used before massage to increase the blood supply and to aid in relaxation of the muscles The patient lies on a table with the foot on a pillow which has been covered with waterproof material and a towel

The source of heat may be a baker infra red lamp or hot packs If a baker or lamp is used, a hot moist towel is first placed over the foot and leg A continuous hot pack may be obtained by the application of hot moist turkish towels or pieces of woolen material The limb is observed to ascertain the temperature, and the heat is adjusted accordingly *The moist heat is continued for fifteen to thirty* minutes until the foot and leg are warm and there is a reddish glow to the skin

Massage. Massage is used for relaxation of muscle spasm to improve muscle tone, and in association with active and passive motion *for correction of deformity*

Light rhythmic strokes are used on the muscles of the lower leg in order to empty the congested vessels above the foot. A light mineral oil is usually used although cocoa butter cold cream or olive oil is sometimes preferred The stroke begins with the fingers at the ankle and continues to the knee with the whole hand following through The muscles on the anterior lateral and posterior portions are treated each in turn About ten strokes are sufficient on each group The pressure is directed upward emptying the veins The dorsum of the foot is treated next The stroke begins at the toes and continues to the ankle The sole is massaged in a similar manner Each toe is then treated separately using two fingers or the thumb and a finger *This is followed by rubbing with gentle pressure* at the interosseous spaces Friction at the ankle joint may be necessary in some cases, and if used is always followed by stroking The muscles of the foot and lower leg are stroked again with kneading interspersed The

treatment ends with a light rhythmic stroking Care is taken to keep the foot and leg relaxed during the entire procedure. If the muscles of the lower leg are extremely congested massage should begin on the muscles above the knee to insure unobstructed venous flow When the posterior group of muscles requires particular attention the patient turns over to lie face downward with the foot extended over the edge of the pillow

The anterior part of the foot can also be influenced by physical therapeutic measures Supination of the anterior part of the foot is counteracted by massage in which each stroke forces the head of the first metatarsal bone in a plantar direction In case the left foot is involved, the left hand supports the foot care being taken to see that the heel is held in varus The right hand grasps the foot just below the heads of the first and second metatarsal bones with the thumb and thenar eminence on the dorsum and the fingers on the sole As the thumb and heel of the hand are drawn distally and medially the head of the first metatarsal is gently forced downward As the stroke continues, the great toe is brought into flexion and abduction at the metatarsophalangeal joint, thus stretching the adductor and extensor muscles as well as the contracted lateral capsule This is an aid in the correction of a valgus deformity at this joint Both hands may be used in a manipulation to aid in reestablishing the anterior arch The foot is grasped by both hands with the thumbs and thenar eminences on the dorsum and the fingers underneath Rhythmic distal and lateral strokes with the right hand and distal and medial strokes with the left, gently force the heads of the first and fifth metatarsal bones down and the middle three upward aided by the upward pressure of the fingers on the plantar surface This reestablishes the anterior arch

Contracted toes are stretched in the following manner the heads of the metatarsal bones are supported by the fingers of the left hand at the same time the thumb holds each toe in turn in extension The contracted tendon is stroked proximally by the thumb of the right hand Friction over the lateral ligaments of the joints may be interspersed with the stroking The muscles should always be massaged to relax them after any manipulative movement

Manual Stretching Contraction of the tendo achillis may be counteracted with passive movement The foot is held in midposition the heel is grasped between the thumb and fingers with the sole of the foot resting on the palm of the hand A steady firm pull is exerted on the heel, forcing the foot into dorsiflexion and stretching the posterior group of muscles Care must be used to avoid pushing on

the forefoot and thereby causing a flattening of the longitudinal arch Stretching should be slow and controlled and within the patient s tolerance.

Exercise. Although walking is a natural and functional exercise, it is usually necessary to teach patients normal gait as described on page 48 For exercise, this gait is exaggerated and practiced for short periods at frequent intervals

REFERENCES

DeLorme, T L. Restoration of Muscle Power by Heavy Resistance Exercises J Bone & Joint Surg., 27-645 1945

Mennell, J B Physical Treatment by Movement, Manipulation and Massage. 5th ed Philadelphia, The Blakiston Company 1945

Speed, J S., and Smith H Campbell s Operative Orthopedics 2d ed. St Louis, C. V Mosby Co., 1949

29

TECHNIC FOR MANIPULATION OF THE FOOT

MANUAL MANIPULATION OF CLUBFOOT

The right foot is held in the left hand, which supports the tibia above the ankle. The right hand then elongates the foot stretching the plantar aponeurosis and correcting the talipes cavus deformity The

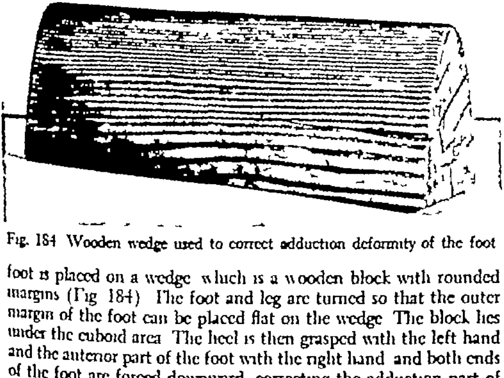


Fig. 184 Wooden wedge used to correct adduction deformity of the foot

foot is placed on a wedge which is a wooden block with rounded margins (Fig 184) The foot and leg are turned so that the outer margin of the foot can be placed flat on the wedge The block lies under the cuboid area The heel is then grasped with the left hand and the anterior part of the foot with the right hand and both ends of the foot are forced downward correcting the adduction part of the deformity The movement is a slow steady one and is repeated until abduction of the anterior part of the foot can readily be attained. The foot is held again with the left hand while the right

*brings the anterior part of the foot outward and upward. This cor*rects the supination of the anterior part and the cavus in the tarsal *area and tends to correct the varus position of the heel* The heel is brought into overcorrection by forcing it into valgus with the foot held over the wedge. The crux of the treatment in congenital club-foot is the overcorrection of the varus deformity

A cast is applied with the cavus deformity corrected, the foot in abduction and pronation and the heel in valgus This cast is then changed and more correction is obtained until overcorrection of these components of the deformity has been established.

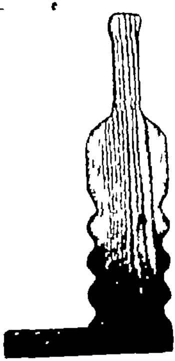


Fig 185 Haglund type of footboard Note the levers to permit increased force which can be controlled manually

The last part of the deformity to be corrected is the equinus which though it is most noticeable, should never be fully corrected until the other components of the deformity are overcorrected since the action of the short tendo achillis is the counter force used to correct the cavus and supination The equinus deformity is corrected by dorsiflexion of the entire foot In most instances the tendo achillis should be elongated and the calcaneus drawn down The tendon lengthening is carried out by *the subcutaneous method* As *the* last fibers are divided, the dorsiflexion is increased until the tendon can be felt to slip as it elongates The foot is brought to a 90 degree angle

and a cast is applied A cast with stockinet and a layer of sheet wadding to protect the heel is preferred.

In the application of the cast it must be remembered never to force the foot into further correction than was obtained by manipulation rather hold a little less correction with the cast than was obtained during the corrective procedure.

Haglund Manipulative Footboard in Recalcitrant and Adult Clubfoot

The patient lies on his back on a firm operating table so that the heel is over the end of the table. A general anesthetic sufficient to give muscle relaxation is administered A 3-inch square of firm felt covers the dorsum of the foot The footboard which corresponds to the size of the foot is placed against the plantar surface (Fig 185) A woven band made of the material used in the cinch or girth of a horse s harness, sewed firmly to make a strong loop is placed over the felt and the board. A stick is put through the loop and used to twist the loop down in the form of a Spanish windlass (Fig 186) As the slack is taken up the force draws the foot down against the board The windlass is released from time to time to permit circulatory recovery At each end of the footboard are wooden handles about 9 inches long The leverage of the wooden handles exerts powerful force which can be controlled by the feel in the hands of the operator The force is repeated until the cavus deformity is corrected. The shortened plantar aponeurosis and flexor muscles are all stretched. In resistant cases the preliminary stretching is followed by plantar fasciotomy and tenotomy and manipulation with the board and Spanish windlass is repeated

After the cavus deformity has been treated the adduction deformity is corrected over the wedge, as described under Manual Manipulation In the adult the body weight of the operator is directed through his hands to increase the manipulative force

The supination and varus are corrected next The footboard is again fastened on the plantar surface and with the handle or upper lever the foot is brought into dorsiflexion so that the tendo achillis is under tension The lateral handle is then used as a lever to force the foot upward into pronation and the heel into valgus This force is repeated several times In most adults the varus at the heel is stubborn and requires additional force from a Thomas wrench

Force is exerted against the equinus deformity by bringing the foot into dorsiflexion The weight of the body of the operator is brought to bear against the handle or upper lever As much correction is taken as can safely be applied without injury to the osseous

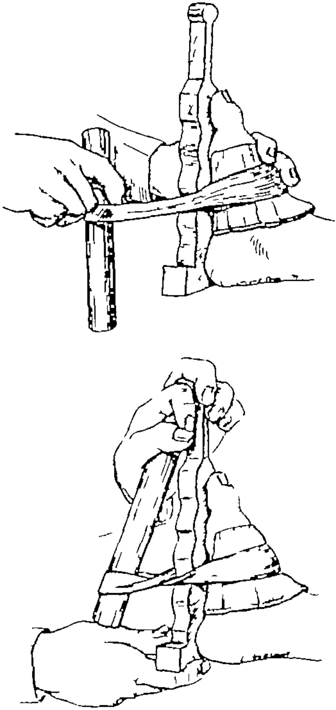


Fig 186 Application of Haglund footboard The loop is screwed down in the form of a Spanish windlass The board fastened to the foot permits leverage to correct the deformity

structures The tissues are stretched rather than torn In this way the maximum correction is obtained without impairment of function If overcorrection is not obtained after the first manipulation the cast is removed after three weeks and the manipulation is repeated Full correction of the equinus usually requires a tendon lengthening operation. This is executed only after the rest of the deformity has been overcorrected

In extremely severe deformities in the adult and recalcitrant recurring clubfoot in children several manipulations may be necessary before overcorrection is obtained The patient walks in the overcorrected position which is held by a cast. To overcome the tendency toward recurrence, this overcorrected position must be held for some time afterward In addition to the cast the position may be held by means of a form fitting leather and steel brace If the tendency toward recurrence is less bilateral irons attached to the heel of the shoe may be the mechanism of choice to hold the overcorrected position The outer side of the heel of the shoe is raised to hold the valgus To hold the overcorrection of the supination or to hold the foot in abduction an elastic band or a flat spring may be attached to the outer side of the sole of the shoe and to a band on the leg

The braces with elastic band or spring are difficult to control A new type of brace has been developed to hold the feet in eversion and permit walking with the feet in the overcorrected position (see p 171)

MANIPULATION OF THE HEEL WITH THE THOMAS WRENCH

The Thomas wrench is an extremely powerful lever and deformity of the heel is usually a resistant deformity to correct (Fig 187) One arm of the wrench is placed below the malleolus and the other above the opposite malleolus the long heavy handle acts as a lever to bring the heel into varus or valgus depending on how the wrench and the force are applied In varus deformity the proximal lever is on the inner side below the medial malleolus The foot extends out over the edge of a firm operating table so that the distal lever can be placed above the lateral malleolus During manipulation the tibia and fibula are held firmly against the table by an assistant, to steady the limb and prevent injury to these bones The wrench is drawn slowly and steadily outward When the tissues no longer give the force is relaxed and the process repeated The handle of the wrench is kept up against the body of the operator thus steadying the movement and giving greater force with the minimum amount of exertion

In valgus deformity the grip of the wrench is reversed and a medial force is exerted

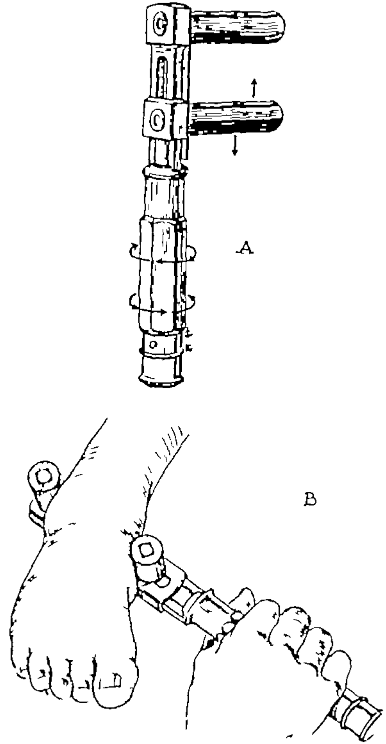


Fig. 187 A. Thomas wrench *B* application of Thomas wrench to correct a varus deformity of the heel

MANIPULATIVE CORRECTION OF PES VALGOPLANUS

The spastic type of pes valgoplanus and pes valgoplanus of long standing with adhesions sometimes require manipulative correction

In the newborn infant with congenital pes valgoplanus cohesive bandage is used. The foot and leg are encircled with several layers to be used as an anchor band The bandage is started on the lateral side of the leg and foot As the bandage is brought under the heel, the heel is drawn into varus The bandage is brought under the heel, the heel is drawn into varus The bandage is continued up the medial side of the leg and fastened to the anchor band This is repeated several times taking more correction each time Another bandage is started on the dorsomedial surface of the foot and as it crosses the sole of the foot the fore part of the foot is brought into pronation The bandage is continued over the dorsolateral surface of the foot, up the leg to above the medial malleolus This is also repeated several times with increased correction each time More circular turns of the bandage are made until the entire foot and leg are covered with the cohesive In order to have a bandage of sufficient strength to hold the correction obtained the entire procedure is repeated with water proof adhesive tape 2 inches wide The bandages are replaced at intervals of one to three weeks depending upon the rate of growth of the infant and the effectiveness of the fixation

When treatment is started immediately after birth the improvement is rapid and a relatively normal appearance is obtained in a short time. The treatment must be carried out, not only until full correction and overcorrection are obtained but also until all tendency for recurrence is eradicated

In adults greater force is required for the manipulative correction Manual manipulation is reinforced mechanically by the Haglund footboard and Thomas wrench The board is placed on the plantar surface of the foot a felt pad is placed on the dorsum and both the board and the foot are encircled with the woven band By using a stick as a lever the band is twisted until the loop has been drawn down to force the footboard against the foot The contracture of the tarsal area is broken down The board has a long lever in the dorsal direction and one in the medial direction which permit increased force to be exerted and controlled by means of the hands These levers are used to force the foot dorsally and medially bringing it into dorsiflexion and the heel into varus Further correction of the valgus of the heel may be obtained by means of the Thomas wrench

The anterior part of the foot is brought into pronation by means of a special wrench consisting of a long and a short lever (Fig 188) The short lever is rounded On the outer surface of the long lever

near the fulcrum a strong buckle is attached A woven canvas band, 2 inches wide, is attached to the buckle at one end, and the other end is passed through the opening of the buckle to form a loop The foot is put into the loop with the dorsum protected by a felt pad, and the band is tightened and held firmly The short lever is underneath the plantar surface of the anterior part of the foot. The long lever is on the medial side of the foot as pressure is exerted on the lever the anterior part of the foot is forced into pronation This

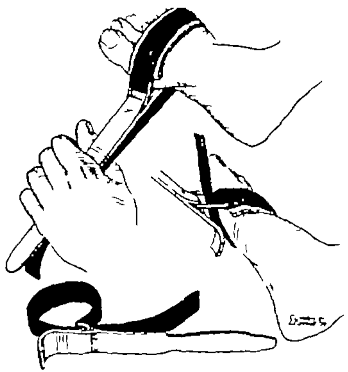


Fig 188 Special wrench and two views showing its application for correction of the supination of the anterior part of the foot

mechanism provides an efficient machine to force the anterior part of the foot into pronation so that the first metatarsal bone is drawn downward and the middle metatarsal bones are forced upward

After manipulative correction of the foot stockinet is applied The foot ankle and posterior surface of the heel are covered with a double layer of sheet wadding and a plaster of paris cast is applied The foot is fixed with the heel in varus the anterior part of the foot in pronation and the foot at a right angle at the ankle joint

TECHNIC OF LENGTHENING THE TENDO ACHILLIS

To lengthen the tendo achillis a division is made of half or a little more than half of the tendon in a transverse direction near its at

tachment to the calcaneus (Fig 189) About 1 to 1½ inches higher a second transverse division is made on the opposite side of the tendon from one half to two-thirds of the tendon is divided.



Fig. 189 Exposed tendo achillis showing rotation of the fibers and incisions used to obtain lengthening (Cummins et al Surg., Gynec & Obst)

To divide the tendon near its insertion a small curved tenotome is introduced through the skin on the medial side When the blade

has passed through the skin it is placed beneath the tendon staying close to its anterior surface. The tenotome is inserted so that the blade is flat The foot of the patient is dorsiflexed putting the tendon under tension and bringing it into prominent relief The tendon is readily palpated and its outline can be felt underneath the skin The tenotome is inserted so that the blade lies beneath the medial half or two-thirds of the tendon, and it is turned so that the blade faces posteriorly With the handle of the tenotome held in the fingers and the thumb pressed over the skin the blade is brought from the anterior surface through the tendon without injury to the skin This divides the plantaris tendon and the medial fibers of the tendo achillis, contributed to mainly by the soleus muscle. The proximal incision is then made in a similar fashion using a tenotome shaped like a small scalpel. It is inserted through the skin on the medial side of the tendon about 1 to 1¼ inches above the distal division With the blade flat, it is passed through the tendo achillis with approximately two-thirds of the tendon between the blade and the skin The blade is then turned to face posteriorly and the posterior fibers are cut against the thumb as a guide, with the tendon under tension The divisions are made in this manner because of the rotation of the fibers of the tendo achillis. In a few instances, where rotation is slight, the lateral fibers may remain intact at the proximal incision These fibers, being muscular at this level, are readily pulled apart as dorsiflexion of the foot is performed As the foot is dorsiflexed, the fingers can feel the divided portions of the tendon slide by as the tendon is lengthened The amount of lengthening desired is obtained. The dorsiflexed position of the foot is relaxed slightly and a cast is applied from the toes to well above the knee.

REFERENCES

Cummins, E. J., Anson, B J., Carr B W., and Wright R. R., with Surgical Commentary by E D W Hauser The Structure of the Calcaneal Tendon (of Achilles) in Relation to Orthopedic Surgery Surg., Gynec. & Obst., 83 107 1946

Haglund P Die Prinzipien der Orthopädie Jena, G Fischer 1923

Korthuelle F F An Orthopedic Lever for Correcting Deformities of the Foot J Bone & Joint Surg., 14 715 1932.

Thomas H O *Diseases of the Hip Knee and Ankle Joints with Their Deformities Treated by a New and Efficient Method* Liverpool, Dobb 1875

White, J W Torsion of the Achilles Tendon Its Surgical Significance Arch Surg., 46 784 1943

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ORTHOPEDIC APPLIANCES FOR THE FOOT

SPLINTS

The simplest splint for the foot, and the one most readily obtained is the pillow splint. A board is inserted between the pillow and the pillow slip one on each side. The foot and leg are placed on the pillow The pillow is then pinned together across the dorsum of the foot with large safety pins the distal end of the pillow is brought up against the plantar surface of the foot and held with safety pins This splint can be made readily and used in emergency

To prevent foot drop while a patient is in bed a posterior splint can be used A form fitting splint is the most efficient as well as the most comfortable. This can readily be made out of plaster of paris bandage To prepare it, the leg and foot are covered with petrolatum or enclosed with stockinet. The length of the posterior surface of the foot and leg is measured and splints of plaster of paris are cut. "Specialist" hard-coated plaster of paris splints about 4 inches wide and 15 inches long may be purchased The foot is held in the mid position A band made of soft lead or a heavy bandage is placed over the dorsal surface of the foot and leg A circular bandage of plaster of paris 4 to 6 inches wide, depending upon the size of the leg is then used as if a form fitting cast were to be applied. Four to six of the prepared plaster splints are immersed in water and quickly withdrawn They are applied and molded over the posterior surface of the foot and behind the ankle. Splints are also placed beneath the toes Two inches of the length may be reflected at the distal end of the splint for reinforcement of the end of the splint which extends beyond the toes The splints are held in place with a second circular bandage of plaster of paris The area in the region of the ankle is reinforced with three turns since this is the point of greatest strain The plaster is molded well until it sets The cast is cut on the dorsal surface with heavy scissors or if desired with a plaster knife, using

the metal splint or bandage as a guide Before opening the cast, transverse lines are drawn with a soft pencil over the anterior part of the cast After it is removed these lines are put into apposition and the margins are held together with a gauze bandage and allowed to dry The anterior part of the cast is cut away retaining only the posterior splint This is fitted to the foot, and the margins are trimmed so that there is no pressure at the edges or at the malleoli (Fig. 190)

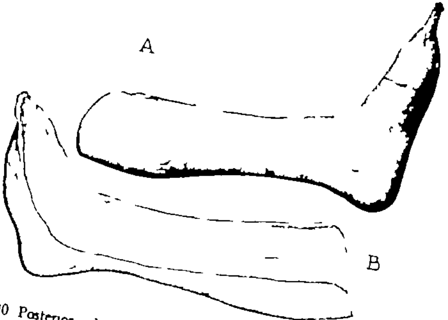


Fig. 190 Posterior splint of plaster of paris Note the extension of the plaster beyond the toes which protects the toes from the weight of the bed clothes A, Medial view of posterior splint; B view to show the smooth, form fitting inside surface

The splint is allowed to dry for twenty four hours the edges are trimmed and the stockinet is turned back and fastened The splint is applied to the posterior part of the foot and leg and one or two layers of sheet wadding are used to cover the anterior part of the limb The splint may be held in place with strips of adhesive or with a 2 or 3 inch Ietra bandage encircling the splint and the limb

An anterior and a lateral splint may also be made of plaster of paris in a similar manner

For more permanent splints a plaster of paris mold of the limb is made with the foot in the midposition The position and the

molding of the model must be accurate A positive is made from the model and a form fitting splint is then constructed by the brace maker This may be made of celluloid or molded leather (Fig 191) These splints have a skeletal structure of steel one transverse and two longitudinal strips are used At times a splint is hammered out of aluminum this is lined with felt and makes a serviceable support

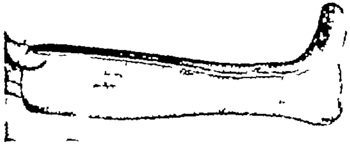


Fig. 191 Posterior molded splint made of leather

Recently I have used Castex wrapped over a positive mold. This makes a light, durable splint which is waterproof

BRACES

Braces are used to prevent the occurrence of deformities and to permit weight bearing and thus to reestablish function They are also used to retain the overcorrected position in the treatment of congenital deformities

It is an accepted principle with me not to correct a deformity with a brace. The brace is primarily a method of retention of the corrected position it increases stability and permits restoration of function Before a brace is applied the deformity must be corrected and normal weight-bearing alignment must exist The improvement of operations for stabilization of the foot and for the prevention of foot drop have displaced to a great extent the need for braces particularly their use as permanent supports

The most efficient is the form-fitting brace modified from the original Hessing type This sort requires an expert brace maker trained in the construction of form fitting braces It also requires exact supervision on the part of the surgeon The expense of construction of such a brace is relatively great and is therefore an item in the consideration of its use (Fig 192)

The simplest type to construct is the double-iron brace. This may be made with an attachment to the heel of the shoe, or it may be attached to a food plate As a general rule, the foot plate should be

the metal splint or bandage as a guide Before opening the cast, transverse lines are drawn with a soft pencil over the anterior part of the cast After it is removed these lines are put into apposition and the margins are held together with a gauze bandage and allowed to dry The anterior part of the cast is cut away retaining only the posterior splint This is fitted to the foot and the margins are trimmed so that there is no pressure at the edges or at the malleoli (Fig 190)

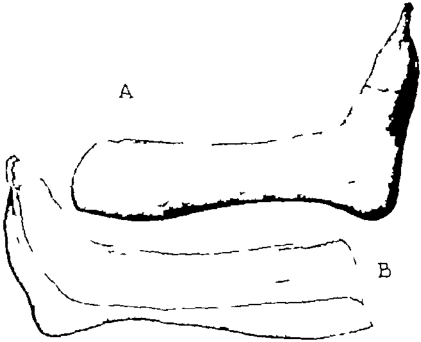


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molding of the model must be accurate. A positive is made from the model and a form fitting splint is then constructed by the brace maker. This may be made of celluloid or molded leather (Fig. 191). These splints have a skeletal structure of steel; one transverse and two longitudinal strips are used. At times a splint is hammered out of aluminum; this is lined with felt and makes a serviceable support.

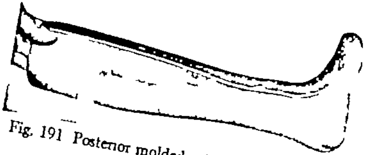


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The most efficient is the form fitting brace modified from the original Hessing type. This sort requires an expert brace maker trained in the construction of form fitting braces. It also requires exact supervision on the part of the surgeon. The expense of construction of such a brace is relatively great and is therefore an item in the consideration of its use (Fig. 192).

The simplest type to construct is the double iron brace. This may be made with an attachment to the heel of the shoe, or it may be attached to a food plate. As a general rule, the foot plate should be

made from a model This brace may be constructed according to a plaster model with more exactness or as is more frequently done from measurements The brace is used for growing children since it can be adjusted and can be replaced with much less expense. A brace can be constructed with a lock at the ankle this will prevent the foot from dropping beyond the point desired (Fig 193)

For foot drop after nerve lesions the elastic support is of some value. This consists in fastening elastic bands to the sole of the shoe.

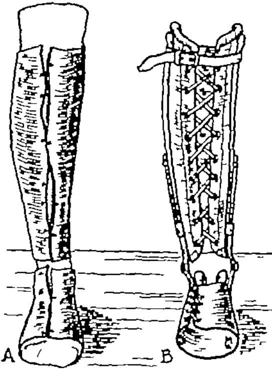


Fig 192 Form fitting brace A, The fitting of leather to a positive plaster mold B the finished brace.

These bands cross over the dorsum and are fastened to a band above the calf of the leg or after the manner of a garter to an abdominal belt or corset. In general, the most useful type of support is the brace with the spring seen in Figure 194

For the retention of position after correction of deformity I have found it valuable to design certain types of braces for individual needs For instance, for a child who had a tendency toward adduction of the foot and internal rotation of the limb the brace illustrated in Figure 96 was designed There is a turnscrew buckle above the ankle which permits the foot to be held in an increasing amount of abduction and external rotation

The Hauser brace* has been designed to hold the abduction and pronation obtained by correction of clubfoot (Fig 96 p 171) The pronation is retained by outside corrections on the shoe A raise of ⅛ inch on the outside of the heel retains the valgus and a Dutchman on the outer edge of the sole, ¼ inch higher than the inner edge, retains the pronation of the forefoot The object of the brace is to keep the feet in abduction This is accomplished by connecting the

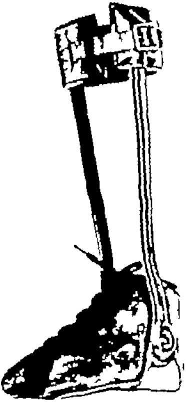


Fig 195 Double-iron brace with lock at the ankle

inner borders of the shoes with two metal rods of unequal length The longer of the two rods is placed in front The lengths of the rods are adjustable to accommodate the length of stride and the amount of correction required The rods are fastened to the shoes by universal joints to permit motions in all directions except adduction

PROSTHESES TO EQUALIZE THE LOWER EXTREMITIES

With shortening of the limb extension prostheses improve the function and add to the appearance and comfort of the patient Minor lengthening may be obtained by putting a lift inside the shoe

* Developed with the technical assistance of Cavour Hauser

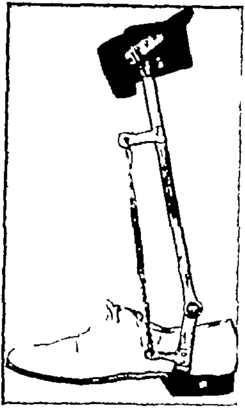


Fig 194 Single iron brace to prevent foot drop



Fig 195 Shoe with elevation, to be worn on well limb to prevent weight bearing on affected limb This is of simple and inexpensive construction

under the heel If a little more lengthening is necessary it may be obtained by increasing the height of the heel on the outside of the shoe. Frequently the well limb is elongated or raised to prevent weight bearing on the affected limb Since this is a temporary therapeutic measure, the elevation should be of simple and inexpensive construction (Fig 195) The sole and heel of the shoe may be raised with a cork insertion When a permanent raise is required and the necessary extension is relatively great, the best cosmetic result is obtained by a specially constructed shoe in which the foot is in plantar flexion

To dispense with the permanent prosthesis, the operation for bone lengthening has been carried out This is a formidable procedure which involves a long time and great expense; it is applicable only in the hands of an expert and in selected cases Equalization of the extremities by shortening the normal limb is simpler but should be advised only after deliberation with due consideration of the risk involved. In growing children interference with epiphyseal growth of the well limb offers a possible solution

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